MINERAL REPORT 25

CANADIAN MINERALS YEARBOOK 1975

Energy, Mines and Resources Canada
Énergie, Mines et Ressources Canada

Minerals
Minéraux

Available by mail from

Printing and Publishing
Supply and Services Canada
Ottawa, Canada K1A 0S9

or through your bookseller.

Catalogue No. M38-5/25
ISBN 0-660-01632-X

Price: Canada: $15.00
Other countries: $18.00

Price subject to change without notice.

Foreword

This issue of the Canadian Minerals Yearbook is a report of developments in the mineral industry for 1975. The 54 chapters dealing with specific commodities were issued in advance under the title Preprints, Canadian Minerals Yearbook 1975 to provide information as soon as possible to interested persons. The Statistical Summary prepared specifically for the Yearbook each year, deals with the overall position of the industry in its national and international perspective; it comprises 69 statistical tables not readily available from other sources. The Company Index provides full and accurate company names and a complete cross reference to corporate activities in the Canadian industry, supported again by pocket map 900A, Principal Mineral Areas of Canada.

The Yearbook is the permanent official record of the growth of the mineral industry in Canada and is preceded by similar reports under various titles dating back to 1886. Those wishing to refer to previous reports should consult departmental catalogues, available in most libraries.

The basic statistics on Canadian production, trade and consumption were collected by Statistics Canada, unless otherwise stated. Company data were obtained directly from company officials or corporate annual reports by the authors. Market quotations were mainly from standard marketing reports.

The Department of Energy, Mines and Resources is indebted to all who contributed the information necessary to compile this report.

October 1976

Editor: G.H. Meldrum
Assistant Editor: R.B. Abbott
Graphics and Cover: N. Sabolotny

Set by Graphic Systems, System 1 phototypesetter, Times Roman typeface 8 on 9 point, and reproduced by offset lithography.

Readers wishing more recent information than that contained in the present volume should obtain the 1976 series of preprints: a complete set costs $15.00; individual copies sell for 50¢ and may be obtained from Publishing Centre, Department of Supply and Services, Ottawa, Canada, K1A 0S9. For shipments outside Canada add 20 per cent to prices shown. Prices subject to change without notice.

Front End Leaf

The spectacular CN Communications Tower is the focal point of this panoramic view of Toronto's skyline. Fifteen thousands tons of cement were used as the binding ingredient for the forty thousand cubic yards of concrete required to construct this tower — the tallest free-standing structure in the world. (Photo courtesy of Canada Cement Lafarge Ltd.).

Frontispiece

View of the open pit from inside the stope above the 800-foot level at Kidd Creek mine at Timmins, Ontario (Photo by Herb Nott & Co. Ltd.)

Contents

General Review

W.E. VAN STEENBURGH

The state of the Canadian economy 1975

The economic recession which started in 1973 bottomed out in 1975, and moderate economic recovery was under way from the second quarter onwards. The rate of inflation lessened to some extent. Gross national product (GNP) at market prices for 1975 rose to $161.1 billion which was 11.4 per cent higher than a year earlier. After discounting for the rise in overall prices, growth in real GNP was 0.6 per cent. This real growth rate was below that experienced in any year since 1954. By comparison, real growth amounted to 3.2 per cent for 1974 and 7.2 per cent for 1973. Figure 1 shows GNP and GNP per capita from 1955 to 1975, in both current and constant dollars.

Corporation profits before taxes fell 1.1 per cent in 1975, compared with increases of 25.1 per cent in 1974 and 39.2 per cent in 1973. The profit share of GNP was 11.5 per cent in 1975, which is high compared to average historical values. On the other hand, labour income, which represents over one half of GNP, rose 15.4 per cent in 1975, which is somewhat less than the phenomenal increase of 18.3 per cent in 1974.

Although overall profits were down somewhat in 1975, they varied considerably among industries. Total mining showed decreased profits, with metal mines recording a large decrease. Profits increased slightly in other mining and substantially in mineral fuels. Total manufacturing recorded decreased profits and among its components the textiles, wood, paper and forestry, and primary metal industries showed large decreases, metal fabricating a slight increase, and the food and beverage, machinery, and the nonmetallic mineral product industries recorded significant profit increases.

A significant part of corporation profits and of nonfarm unincorporated business income was due to gains in the value of inventories which resulted from the turnover of goods at rising prices. The inventory valuation adjustment, which removes from income those profits which do not reflect current production, amounted to −2.9 billion dollars in 1975.

Real domestic product (RDP). Figure 2 indicates the growth in RDP for selected Canadian industries

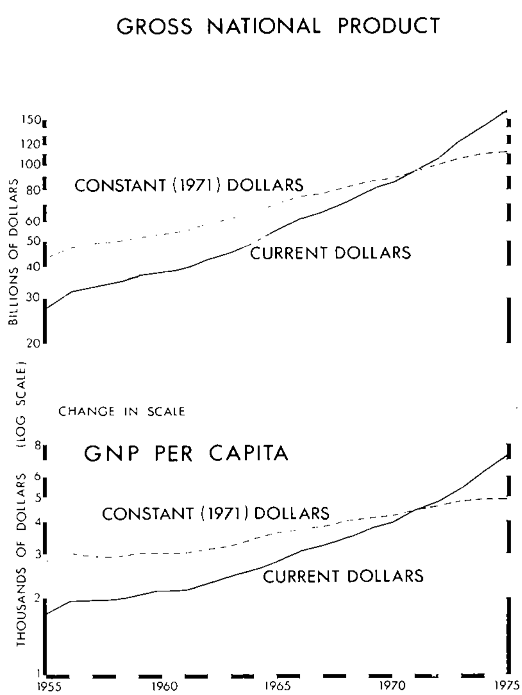


Figure 1

since 1960. RDP measures the country's output of goods and services and differs from GNP in that it is a measure of the production rather than of the income of Canadians. The RDP index (1971=100) for all Canadian industries for 1975 was 117.6 compared with 117.3 a year ago, a rise of only 0.3 per cent.

Production of mines, quarries and oil wells for 1975 decreased 7.4 per cent from 1974, with metal mines down 6.9 per cent, mineral fuels down 7.2 per cent, and nonmetal mines down 16.1 per cent. Manufacturing

---

Statistical data were compiled by the Information Systems Division from information provided by Statistics Canada.

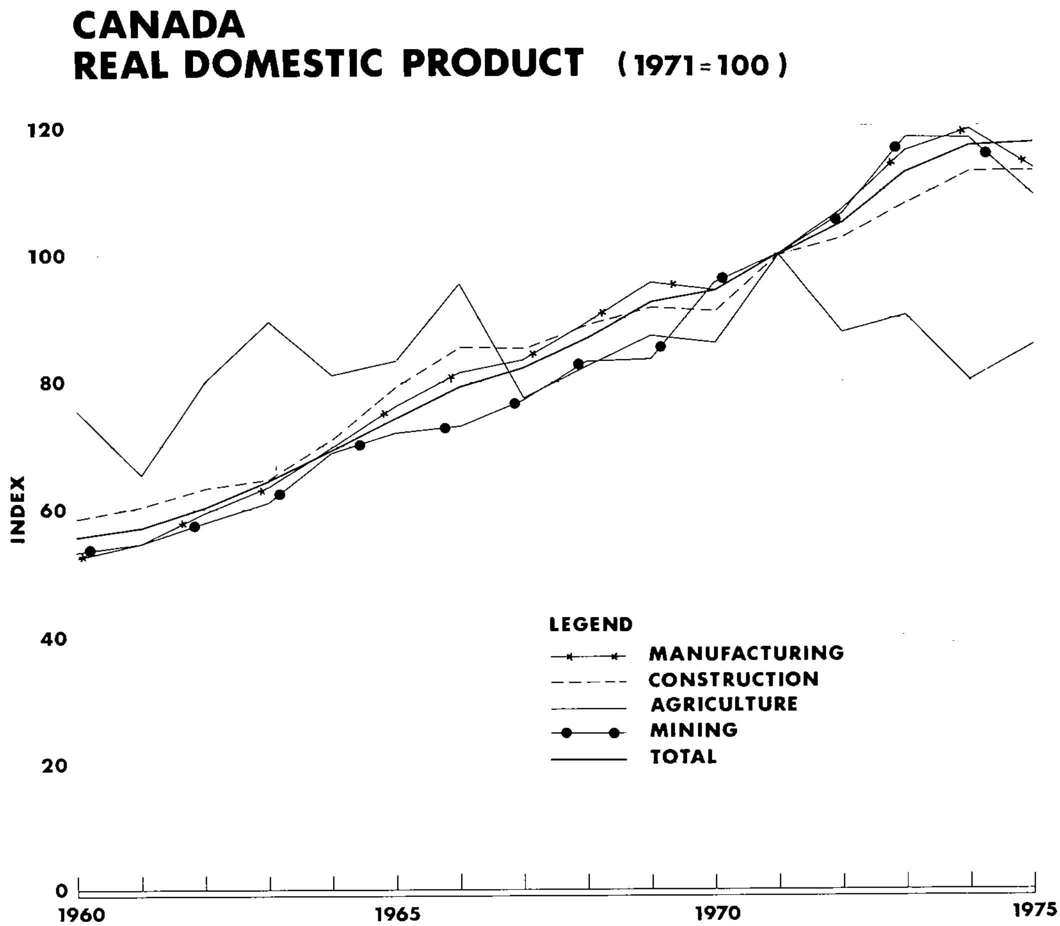


Figure 2

production for 1975 decreased 4.9 per cent from 1974 and among its components the food and beverage industries production was up 0.9 per cent; wood, down 9.2 per cent; paper, down 18.9 per cent; printing and publishing, up 1.1 per cent; primary metals, down 3.9 per cent; metal fabricating, down 4.2 per cent; machinery industries, down 0.4 per cent; transportation equipment, down 1.2 per cent; nonmetallic mineral products, down 3.9 per cent; and chemical and chemical products industries, down 0.2 per cent.

Labour force and unemployment. The year 1975 brought little improvement to the Canadian labour scene. The nation's total labour force grew from 9.70 to 10.06 million people, an increase of 3.7 per cent which was only slightly less than the 4.1 per cent growth for the previous year. However, the 1975 increase in employment was only 1.9 per cent compared to 4.4 per cent in 1974. As a result, unemployment increased by 178,000 people to a total of 697,000 people in 1975, whereas virtually no change was recorded in 1974. The unemployment rate increased significantly to 6.9 per cent for 1975 from 5.3 per cent for 1974. Figure 3 illustrates trends in Canada's population, labour force, and unemployment rate from 1955 to 1975.

All regions recorded limited growth in employment in 1975. The increase in British Columbia was 2.2 per cent (22,000 new jobs); Quebec, 1.5 per cent (37,000 new jobs); Ontario, 1.8 per cent (63,000 new jobs); and the Prairies, 3.0 per cent (46,000 new jobs).

The service sector provided the major contribution to the growth in employment in 1975, with an increase of 6.0 per cent or 346,000 people. By comparison, employment in the goods-producing sector fell by 3.6 per cent or 120,000 people. Among industries in the goods-producing sector, mining employment which increased 3.3 per cent in 1974, showed an increase of 10.2 per cent or 13,000 people to a total of 140,000

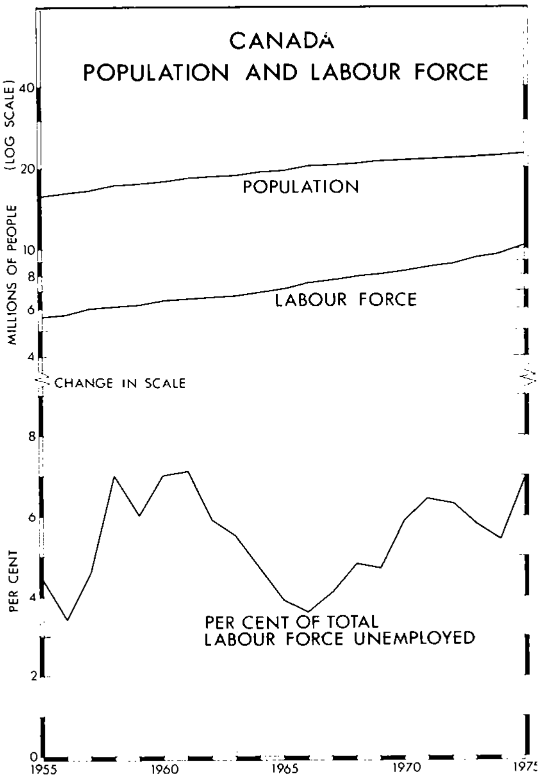


Figure 3

people in 1975. Manufacturing employment decreased substantially by 6.6 per cent (134,000 fewer jobs) in 1975 compared to a 2.9 per cent increase in 1974. Construction employment increased 2.0 per cent (12,000 new jobs) in 1975 compared to an 8.9 per cent increase a year earlier.

Labour disputes increased significantly in Canada during 1975 with 11.5 million man-days lost in work stoppages,* an increase of 18.6 per cent over 1974. Work stoppages in mines, quarries and oil wells increased 116.5 per cent to 1.1 million man-days. Continuing inflation contributed to labour unrest.

Prices. Prices at both the retail and wholesale levels rose somewhat less sharply in Canada, following the general easing of inflation in most industrial countries as a result of the international recession. According to statistics Canada, inflation** rose at a rate of 10.8 per cent in 1975, Canada suffered a somewhat milder recession than the average for the Organization for Economic Co-Operation and Development (OECD) countries. The slowdown in the rate of inflation in Canada came later and was smaller than that in the United States, the Federal Republic of Germany and Japan. Mounting concern over Canada's inflation prospects and the severe domestic and external difficulties which these would entail led the government to introduce an anti-inflation program which became law in late December.

The consumer price index (1971 = 100), which is designed to measure typical family living costs, reached 138.5 for 1975, a rise of 10.8 per cent over 1974. From 1974 to 1975, food prices went up 12.9 per cent, housing 10.0 per cent, clothing 6.0 per cent, and health-personal care 11.4 per cent.

The purchasing power of the consumer dollar, in terms of 1971 prices, stood at 72 cents for 1975.

Canada's total wholesale price index (1935-39=100) was 491.3 for 1975, a rise of 6.5 per cent over the preceding year. During this period, the price of vegetable products fell 3.5 per cent, textile products fell 4.2 per cent, nonferrous metals remained constant, nonmetallic minerals rose 18.3 per cent, and iron products rose 14.8 per cent.

Balance of international trade. Canada's current account was a record deficit of $4,965 million at the end of 1975. This represented an increase of $3,473 million over the deficit of $1,492 million registered in 1974. The factors contributing to the loss were the balance of merchandise trade which became negative in 1975 (a decrease of $2,337 million from 1974), and non-merchandise transactions of which the deficit increased by $1,136 million in 1975. Trends in merchandise and non-merchandise trade from 1955 to 1975 and in the current account from 1960 to 1975 are illustrated in Figures 4 and 5 respectively.

During 1975, the value of merchandise exports increased to $33,347 million, up 2.3 per cent over 1974, largely due to price increases for many of Canada's export commodities. The volume of exports was generally down, as a result of the world-wide recession. There was little change in the value of shipments to Canada's principal markets, with exports to the United States and the European Economic Community (EEC) up slightly and those to Japan down somewhat. Exports to Central and South America showed a slight decrease and those to Eastern Europe (including Russia) a significant increase. The United States market received 65.4 per cent of total shipments in 1975. The largest increase in the value of exports was recorded for inedible end products. Considering some of the major commodities, the value of exports of wheat for 1975 showed little change from 1974, other cereals increased, iron and nickel ores and concentrates increased whereas copper ores and concentrates decreased, crude petroleum and asbestos were down

---

*In calculating time lost, only the workers directly affected by the strike or lockout are taken into account; time lost by workers indirectly affected, such as those laid off as a result of a work stoppage, is not included.

**Measured by Statistics Canada as the difference between overall GNP and real GNP.

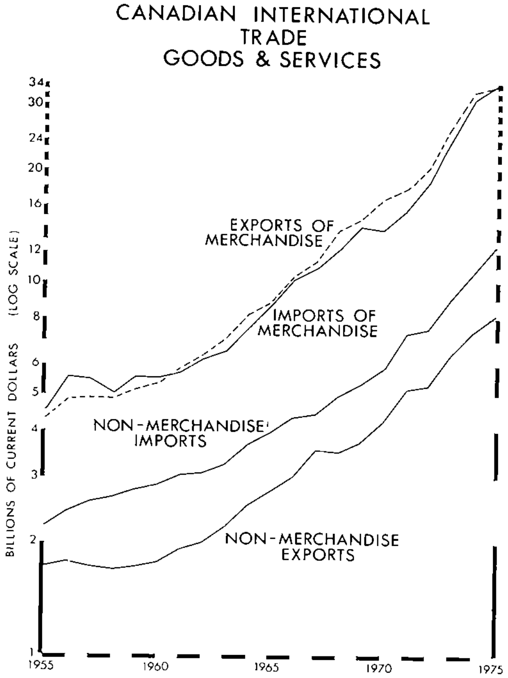


Figure 4

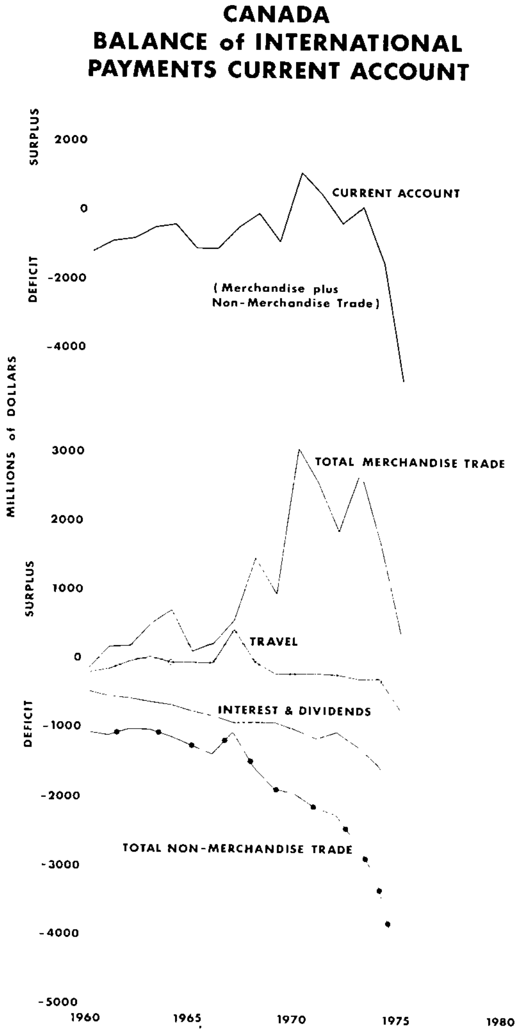


Figure 5

and natural gas up significantly, lumber was down, wood pulp and newsprint paper remained about the same, aluminum, copper, nickel and zinc metals and alloys were down, industrial and agricultural machinery up, and the value of exports of motor vehicles and parts were up in 1975.

Merchandise imports increased to $34,635 million in 1975, a growth of 9.3 per cent from 1974. World-wide inflation contributed to the rising price of imports into Canada. The value of imports from the United States, the EEC and the Middle East increased in 1975 whereas those from Japan and Central and South America decreased to some extent. The United States supplied 68 per cent of Canada's total imports in 1975. Commodities such as industrial and agricultural machinery, coal and crude petroleum showed the largest increase in imports.

The deficit on non-merchandise transactions continued to rise in 1975. At $4,326 million, it was $1,136 million greater than in 1974. With the exception of other services, the net balances on all service items worsened. The largest item was the interest and dividends account, with a $441 million increase in the deficit to $1,970 million. The deficits on freight and shipping and travel increased by $135 million and $443 million respectively, while the deficit on other services fell by $75 million to $1,200 million.

During 1975 there were increases in the prices of both exports and imports. These increases were associated with Canadian and world-wide inflation. The export price index (1971=100) for all sections increased to 172.9 in 1975, a rise of 10.6 per cent from 1974. The inedible crude materials section showed the largest increase to 16.5 per cent, followed by inedible fabricated materials at 14.4 per cent; the live animals section recorded a 17.6 per cent decrease. Changes in the export price indexes for some commodities of particular interest were wheat, down 5.2 per cent; iron ore and concentrates, up 34 per cent; copper ores and concentrates, down 42.7 per cent; nickel ores and concentrates, up 30 per cent; crude petroleum, up 12.6

per cent; natural gas, up 123.2 per cent; coal, up 80.6 per cent; and asbestos, up 30.7 per cent.

The import price index (1971=100) for all sections increased to 157.1 for 1975, a rise of 15.6 per cent from 1974. Changes in the import price indexes for some commodities of particular interest were fresh fruit, up 14 per cent; cocoa, chocolate, coffee and tea, up 10.8 per cent; coal, up 59.3 per cent; crude petroleum, up 26.4 per cent; industrial machinery, up 21.9 per cent; and cars, trucks and parts, up 16.6 per cent.

Figure 6 illustrates the behaviour of net capital movement in the Canadian balance of international payments from 1955 to 1975.* The total net capital inflow in 1975 amounted to $4,561 million, a rise of over $3 billion from $1,516 million in 1974. The net inflow of long-term capital in 1975 rose sharply by over $3.2 billion to $4,106 million. This mainly reflected increased sales of new Canadian issues of bonds and stocks abroad. Short-term capital movements in 1975 led to a net capital inflow of $455 million, a fall of $190 million from 1974. The main changes were a decrease in the net foreign currency claims of the Canadian chartered banks on non-residents which provided a capital inflow, and an increase in Canadian non-bank holdings of short-term funds abroad which provided a capital outflow.

Capital and repair expenditures. Total investment, including both capital and repair expenditures, on construction and machinery and equipment in Canada during 1975 was $47.7 billion at current prices. This was $5.7 billion or 13.5 per cent higher than in 1974.

Investments for 1975 were more substantial in the business sector than in the non-business sector. Sectors showing the largest percentage increases in 1975 compared with 1974 were commercial services, 31.0 per cent; agriculture and fishing, 24.1 per cent; utilities, 22.1 per cent; and mines, quarries and oil wells, 21.5 per cent.

Trends in the total investment in major Canadian industrial sectors from 1955 to 1975 are illustrated in Figure 7. The total investment forecast for 1976 is $53.3 billion, a rise of 11.7 per cent over 1975.

International background

During 1975 the world economy began to recover from the longest and sharpest international recession encountered since the 1930s. At the beginning of the year, real output was falling and unemployment was rising in most countries. By the end of the year, moderate economic expansion was under way in most industrial nations. This turn-around in economic performance reflected a number of influences. Resistance to the recession was provided by the extensive income support and welfare systems which exist in virtually all industrial nations. In addition, most governments introduced fiscal and/or monetary policies in late-1974

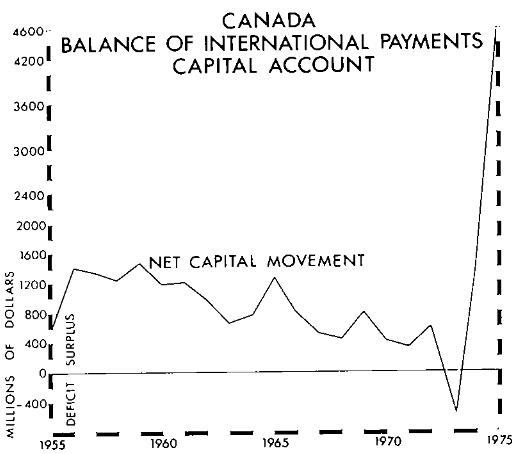


Figure 6

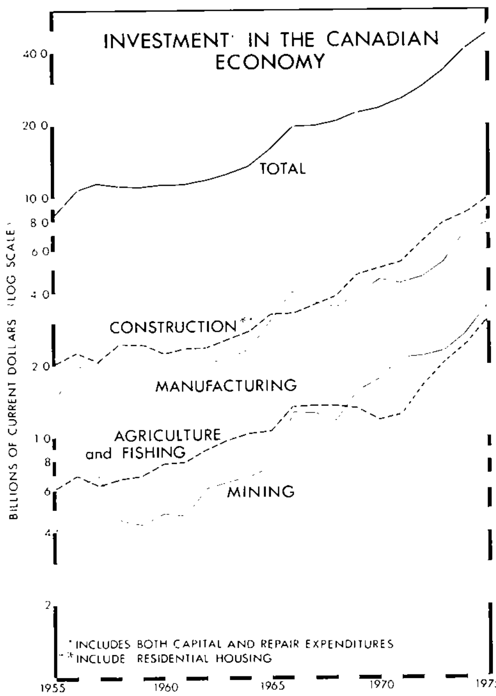


Figure 7

*Mineral exports contribute substantially to improving the merchandise trade balance of the current accounts, but because of data problems the contribution of the mineral industry on net capital movements is not known.

and in 1975 to promote economic expansion. Business enterprises began to stabilize their inventories and, as the speculative excesses in commodities of 1973 and 1974 were dissipated, a new base for recovery in demand and output began to appear.

The rate of inflation eased to some extent during the year in many industrial countries. Among the contributing factors were the world-wide recession, a decline in commodity prices, a stabilization of oil prices, and relatively good food crops in 1975. Moderation was evidenced in nominal wage increases in a number of countries, notably Japan, the Federal Republic of Germany and the United States. The balance of payments deficits were generally smaller in 1975 among the industrial countries. The recession contributed to a decrease in imports, notably oil, whereas exports were increased to the oil-exporting countries. In contrast, the developing countries ran their combined current account deficit substantially above the high level recorded in 1974. Unemployment increased to historically high levels in 1975 as a result of the recession and the moderate nature of the recovery. The volume of world trade decreased by about six per cent from that of 1974. Inflation, high levels of unemployment, and considerable unutilized productive capacity remained major problems in the industrial world during 1975.

The floating of the major currencies, which became prevalent in early 1973, continued during 1975. There were considerable fluctuations in the exchange rates which compensated to a large extent for the different inflation rates occurring among countries.

The year 1975 saw an extensive increase in the North-South dialogue between the developed countries, the less-developed countries (LDCs) and the oil-exporting countries. The atmosphere and content of many of the discussions reflected the influence of the 1973-74 energy crisis. The less-developed countries, which had been suffering under the inflationary spiral since the late 1960s, received a bruising economic setback from the quadrupling of crude oil prices between October 1973 and January 1974 and from the subsequent world-wide recession of 1974-75. Their demands for concessions from the industrially-developed countries in such problem areas as relief from accumulated debts, preferred access to markets, adequate and stable prices for primary commodities, industrialization and technology transfer, increased in vigour. They were supported in many of their demands by the oil-exporting countries. The developed countries were concerned, to a large extent, with the security of supply and price of crude oil. Among the 1975 fora of the North-South dialogue were the Special Session of the United Nations General Assembly in September and the Conference on International Economic Co-Operation in December. Several members of the Organization of Petroleum Exporting Countries (OPEC) emerged as major aid donors to the less-developed countries in 1975. Traditional donor countries, on the other hand, found it difficult to maintain their aid programs in real terms in the face of international inflation and various domestic economic problems.

Throughout 1975, members of the International Monetary Fund (IMF) worked towards agreement on a number of amendments to the Articles of Agreement of the IMF and on enlarged quotas for member countries. After difficult negotiations among the various advisory and directing groups, agreement was finally reached in January 1976. The decisions are now to be put before the member countries for ratification, with a view to implementation sometime in 1977.

An overall increase of 33 per cent in quotas, which determine member countries' voting power, subscription payments and borrowing opportunities, was proposed. The share of the oil-producing countries would double, that of other developing countries would be maintained at its current level, and the share of the developed countries would drop by 5 per cent. The exchange rate arrangements provide for the possibility of an eventual return to a system of fixed exchange or par values, if a large majority of the member countries so desire. They also provide a legal basis for member countries to adopt alternative approaches, such as floating exchange rates, and to maintain them even if other countries return to par values. The official status of gold would be eliminated in the international monetary system, and the official price of gold as well as obligations to make settlements with the IMF in gold would be abolished. Central banks would be permitted complete freedom to buy and sell gold on private markets. The Fund intends to return one sixth of its present gold holdings to members at the official price in proportion to their quotas in the Fund and to sell one sixth at market prices for the benefit of the developing countries. Profits from the latter sale will be put into a trust fund to provide concessional balance of payments financing for the poorest developing countries within the IMF.

The IMF Oil Facility was the major official arrangement utilized in 1975 to help countries with balance of payment difficulties arising from the higher price of crude oil. Member countries were able to obtain additional Special Drawing Rights and a Subsidy Account was developed to reduce the interest burden on the most seriously affected countries which had borrowed from the Facility. The operations of the Oil Facility will soon terminate. However, the IMF Interim Committee agreed in January 1976 that the lending limit on the regular credit tranche of the Fund should be increased until the expanded IMF quotas are put into effect, probably in mid-1977.

The Financial Support Fund of the OECD, not yet ratified by all member governments, was established in April 1975 as a lender of last resort to OECD members. The World Bank created a new facility late in 1975 called the *Third Window* which will provide an interest subsidy on loans to developing countries.

Negotiations were begun on capital increases for the World Bank and its affiliate, the International Finance Corporation, and the resources of the regional development banks, i.e., the Inter-American Development Bank, the African Development Bank and the Asian Development Bank, were strengthened during the year. The less-developed countries (or multinationals operating in LDCs) are increasingly being able to obtain secure loans at favourable rates of interest in order to finance capital investment projects. When they become operational, many of such projects in mining, smelting and refining will come into direct competition with similar industries in Canada.

The surplus of OPEC oil funds was greatly reduced in 1975 from that of the previous year, but the recycling of these funds was still an important source of financing for a number of developed and developing countries. OPEC countries increased their lending to international organizations, including the IMF Oil Facility, and direct lending to both developed and developing countries, much of which was placed in medium- and long-term investments, including government securities, corporate bonds and equities.

At the request of France, the Economic Summit Conference was held in November 1975 at the Château de Rambouillet in France to discuss international economic and monetary problems. The meeting was attended by the heads of government of France, the Federal Republic of Germany, Italy, Japan, the United Kingdom and the United States. One of the main results was that the United States and France reached an agreement ending their long differences concerning the question of present and future exchange rate arrangements.

The Tokyo Round of multinational trade negotiations under the General Agreement on Tariffs and Trade (GATT) progressed slowly throughout 1975 because of both prevailing unsettled economic conditions and the magnitude of the negotiations. By the end of 1975, it appeared that most of the procedural difficulties had been settled.

Mineral industry

Mineral production. In 1975, the total output of Canadian minerals, including metals, nonmetals, structural materials and mineral fuels, reached a record level of $13.4 billion compared with $11.7 billion the previous year. This was more a reflection of increases in price than of increased volume of production.

The highest production value was in the mineral fuels sector, including coal, natural gas, natural gas byproducts and crude petroleum, which rose to $6.85 billion in 1975 from $5.20 billion in 1974. Alberta's output increased to $5.83 billion in 1975 from $4.38 billion in 1974.

Metal mining production had a value of $4.81 billion in 1975, down minimally from $4.82 billion in 1974. Ontario was the leading province in metals output with a production value of $1.96 billion, down from $2.05 billion in 1974.

In nonmetal mining, production value was $929.2 million in 1975 compared with $895.4 million in 1974. Leading minerals in the group were asbestos at $266.9 million in 1975, down from $302.0 million in 1974 and potash at $346.8 million, up from $308.9 million in 1974.

The total value of structural materials was $806.7 million in 1975, down from $828.3 million in 1974. Leading materials were cement at $265.3 million, down from $274.6 million; sand and gravel at $260.3 million, down from $264.0 million; and stone at $170.7 million, down from $177.2 million in 1974.

Figure 8 illustrates growth of the three major sectors of the Canadian mineral industry between 1960 and 1975. The value of mineral production has grown at about 10.6 per cent a year during the period with mineral fuels growing at a higher rate than either metallic or industrial minerals. During 1975, the per capita value of mineral production went up by $64.55 to $587.85, while mineral production as a percentage of GNP rose from 8.1 to 8.3.

Figure 9 shows the distribution of mineral production by commodity and by province for 1975. As in 1974, petroleum was the dominant mineral commodity in value of output with 28.2 per cent of the total. In terms of provincial mineral production, Alberta made the largest single contribution, 44.8 per cent of the

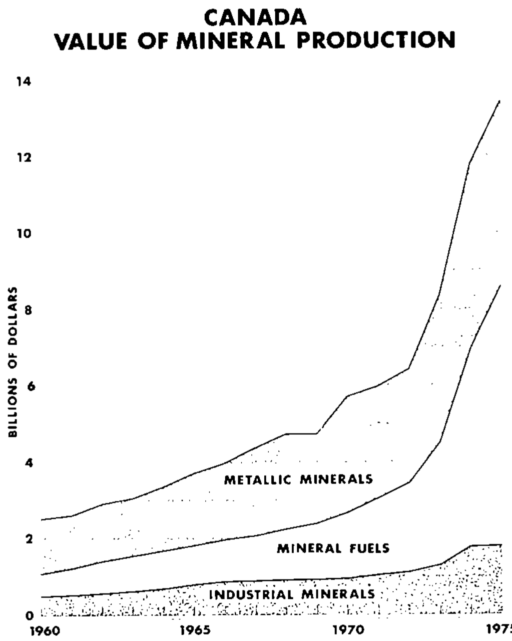


Figure 8

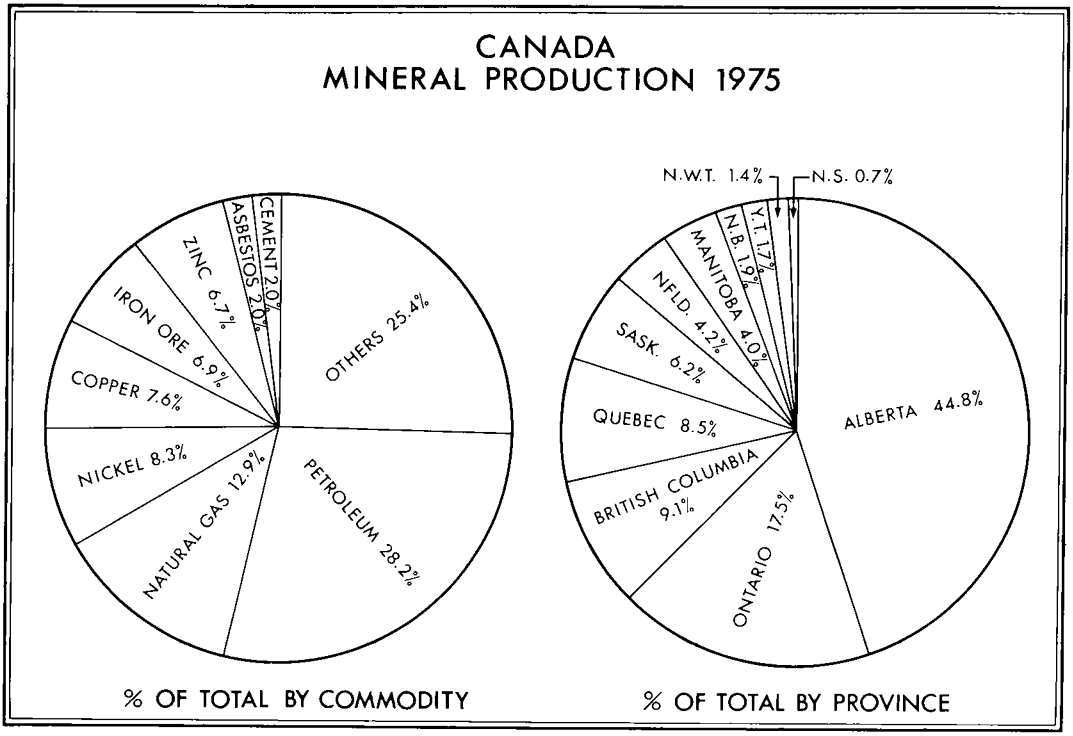


Figure 9

total, followed by Ontario which contributed 17.5 per cent.

Mineral prices. Trends in the wholesale price indexes of mineral products since 1951 are shown in Figure 10. The iron products index, which has been the highest mineral industry price index in recent years, reached 537.7 in December 1975. This was a 12.1 per cent increase over 1974, compared with the nonferrous metals index which went up by only 0.4 per cent, nonmetallic minerals which rose 16.1 per cent, and the general wholesale index which rose 3.7 per cent.

The Prices of many minerals, especially the nonferrous metals, stabilized or decreased in 1975, despite continuing inflation. At year-end, the Canadian producer price* for copper was 63.38 cents a pound, down from 73.0 cents at the end of 1974; zinc remained constant at 37.0 cents a pound; lead, 19.07 cents a pound, down from 21.5 cents; and nickel was $2.20 a pound, up from $1.91 a year ago.

Mineral trade. Canada exported $11.2 billion worth of crude and fabricated minerals during 1975, with the United States buying the bulk of mineral exports, 68.0 per cent. Sales to Japan accounted for 9.1 per cent, Britain 6.4 per cent, and the European Economic Community** 8.0 per cent. Figure 11 illustrates the declining share of the value of mineral exports to Britain over the last decade and the increased portion to Japan and other countries.

Trends in Canadian mineral trade since 1964 are given in Figure 12. For 1975, the value of mineral exports, including both crude and fabricated mineral products, was $11,201.1 million, only 0.2 per cent higher than a year ago. Mineral exports of crude and fabricated materials as a share of total Canadian trade decreased slightly in 1975 to 34.7 per cent from 35.6 per cent in 1974. During this period, the share of exports of mineral fabricated products, which had averaged 13.4 per cent, fell to 11.0 per cent during 1975, while crude minerals moved from an average 17.5 per cent to 23.7 per cent.

Mineral investment. Trends in mineral investment in durable physical assets, including both capital and repair expenditures, for six major mineral sectors from 1960 to 1975 are illustrated in Figures 13 and 14. In mining, investment in mineral fuels in 1975 was $1.9 billion or 28.6 per cent higher than 1974, compared with nonmetal mines at $479.1 million, a rise of 13.6

*Applicable to North American markets.
**Excludes the United Kingdom.

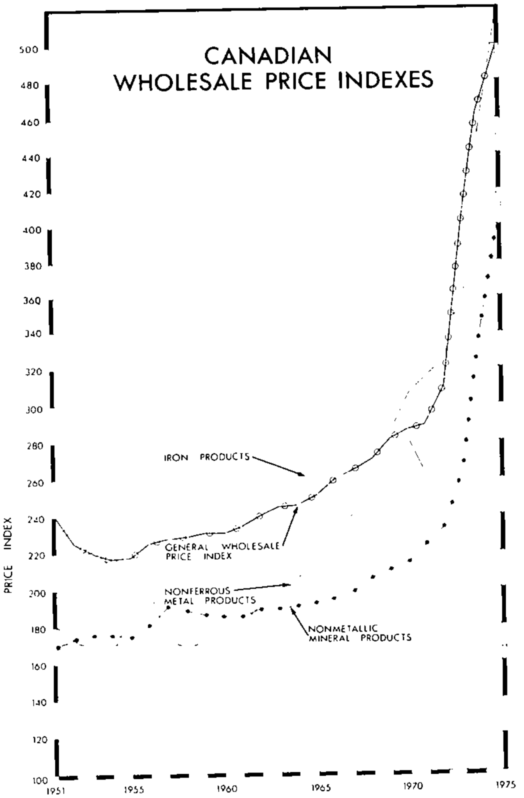


Figure 10

per cent. Similarly, in mineral manufacturing, investment in nonmetallics at $335.9 million was 6.2 per cent higher than in 1974, compared with petroleum and coal products at $582.6 million, a rise of 7.8 per cent, and primary metals at $1,445 million, an increase of 15.0 per cent.

Return on invested capital. Figure 15 compares the average 1964-1975 rate of return on invested capital* for various sectors in the Canadian mineral industry with the total of all Canadian industries. Metal mines show the highest average rate of return at 12.7 per cent and mineral fuels the lowest at 9.1 per cent compared with the total of all Canadian industries at 11.3 per cent. The relevant values in 1975 were in some cases higher and in some cases lower than the average values. The rate of return in metal mines for 1975 was 10.1 per cent, in mineral fuels 21.6 per cent, and in all industries 13.7 per cent.

In 1975, the rate of return on investment in the mining industries** was 15.6 per cent. This is a relatively high rate of return compared to that of the past ten years when the highest level was 18.2 per cent in 1974 and the lowest was 7.1 per cent in 1972. In the mineral-based manufacturing industries,*** the 1975 rate of return was 15.0 per cent. This rate is also comparatively high in view of its fluctuation between 7.9 and 9.8 per cent from 1966 to 1972 and upward to 18.2 per cent in 1974.

Outlook

The world economy. By the end of 1975, economic recovery from the world-wide recession of 1974-75 was under way to a moderate degree in most industrial countries. Output is increasing, balance of payments are generally improved over 1974, and the rate of inflation has eased somewhat. Unemployment remains a major problem, and some economists are expressing doubts as to the length and strength of the emerging recovery.

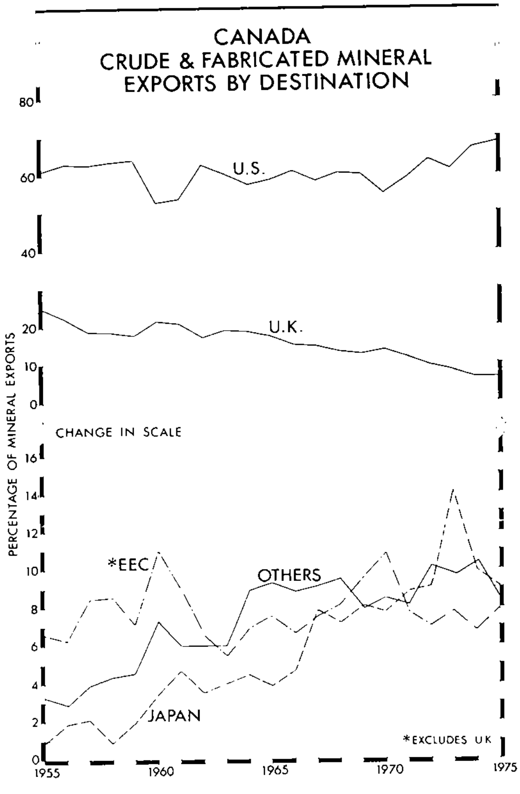


Figure 11

*Pre-tax profit/(total assets minus total current liabilities) x 100.
**Includes metal mines, nonmetal mines, and mineral fuels.
***Includes primary metals, nonmetallics, and petroleum and coal products.

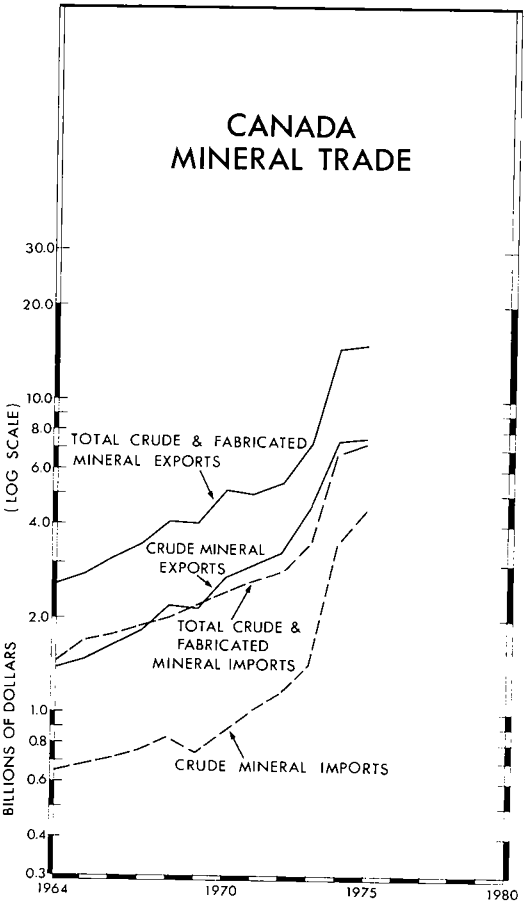


Figure 12

Many less-developed countries (LDCs) have not recovered from successive blows of the inflationary spiral, the quadrupling of oil prices, and the recession. Their demands for a New International Economic Order increased in vigour during 1975. Among the resulting changes, several international organizations were either created or expanded to provide additional loans to LDCs and to fund LDC projects. The 1975 Lomé agreement concluded between the European Economic Community and the LDCs provides duty-free entry of LDC exports to the EEC and a guaranteed income from the exports of a number of such commodities. Similar agreements between LDCs and other countries, such as the United States, appear to be in the offing under the auspices of the United Nations.

The real economic output of the industrial nations is expected to grow on the average of 4 per cent a year over the next several years, which is less than during the last two decades. International trade will also increase at a lower rate. High energy costs will contribute to the slower growths. The Tokyo Round at GATT appears to be making limited progress toward further reductions of tariff and non-tariff barriers to trade. The social tensions and political instability in various areas of the world show little sign of improvement. Environmental controls are increasing. Government intervention in industry, high-cost welfare programs and high taxes will probably remain, which could provide some drag to growth.

Given normal food crops and political stability, world-wide inflation can be expected to diminish somewhat as governments generally maintain restrictive fiscal and monetary policies. The unemployment rate should improve to some extent as economic recovery gets under way. The floating exchange rate will remain in effect for several years in order to provide some isolation for the economy of one country from changes taking place in another. In the short-term, it is not anticipated that any other supply cartels for raw materials will have anywhere near the success experienced by the oil exporters' cartel.

The Canadian economy. Canada suffered a milder recession in 1974-75 than the average of the OECD countries. Although the wage-price spiral abated somewhat in 1975, it was not wrung out by a severe economic depression. The Bank of Canada proclaimed limits on the growth of the money supply in November 1975 and the government established wage and price controls in December.

The recovery of the Canadian economy should follow that of the industrial world over the next several years. Gross National Product in real terms should increase by about 4.5 per cent in 1976 and 4 per cent in 1977.

The rate of inflation should decrease, given the better-than-average food crops in 1975, the slow economic recovery, and restrictive government policies. Unemployment should diminish to some extent as the limited recovery gets under way, but will remain high by historical standards. Merchandise trade will continue to show slow growth as the price of many of Canada's export goods remains high and export opportunities continue to be limited by poor economic performance in other parts of the world. The government will probably keep interest rates above those in the United States in order to attract foreign capital to balance the international payments and help finance government and capital expenditures.

The mineral industry. The mineral industry accounts for about one third of all Canadian exports, contributes to the prosperity of all Canadians, and is crucial to the nation's foreign trade balance. Canada is endowed with considerable mineral resource wealth and the industry has been healthy and competitive in world markets. However, several recent factors tend to pose some questions as to the industry's future international viability.

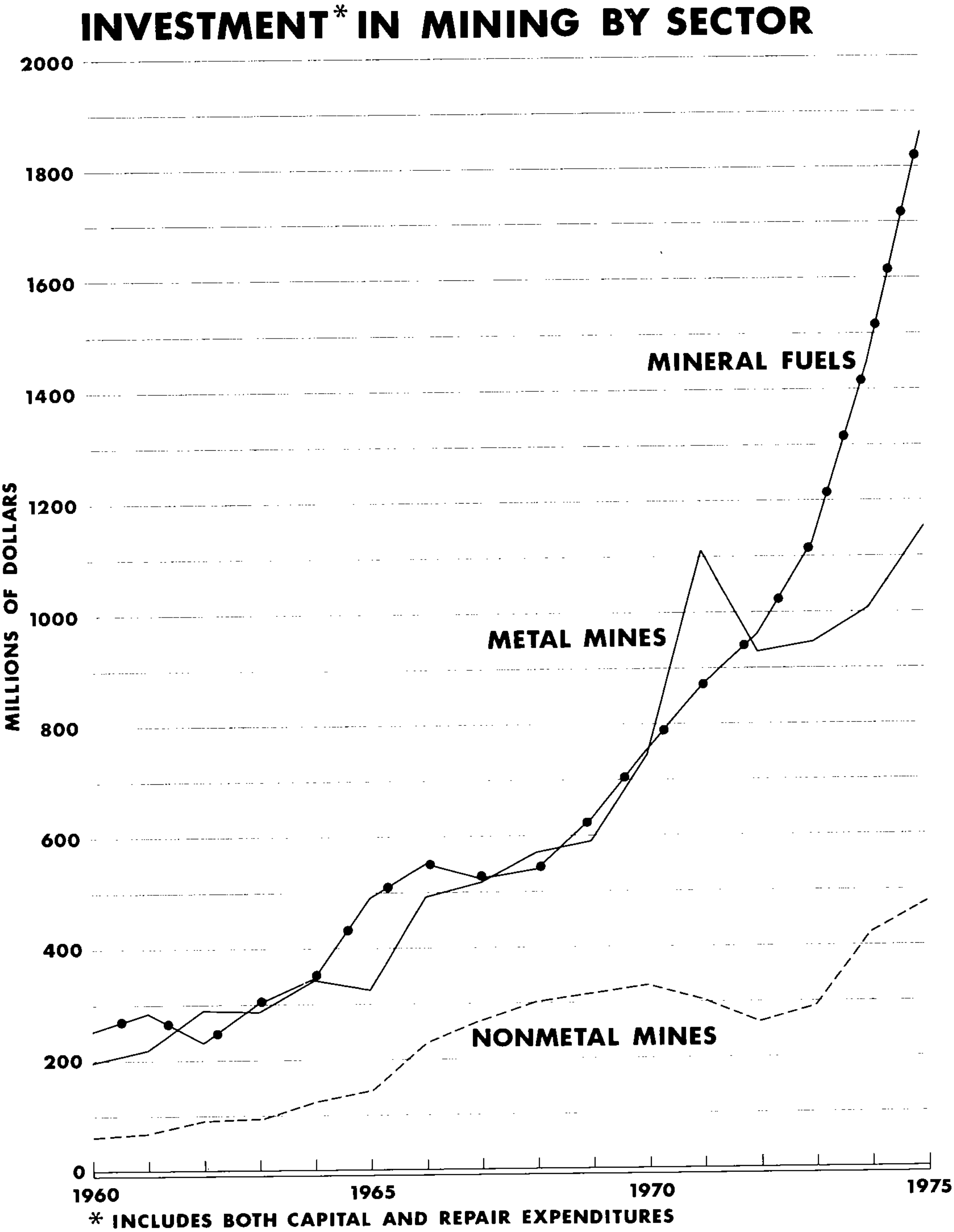

INVESTMENT* IN MINING BY SECTOR
2000
1800
1600
1400
1200
1000
800
600
400
200
0
MILLIONS OF DOLLARS
MINERAL FUELS
METAL MINES
NONMETAL MINES
1960
1965
1970
1975
* INCLUDES BOTH CAPITAL AND REPAIR EXPENDITURES

Figure 13

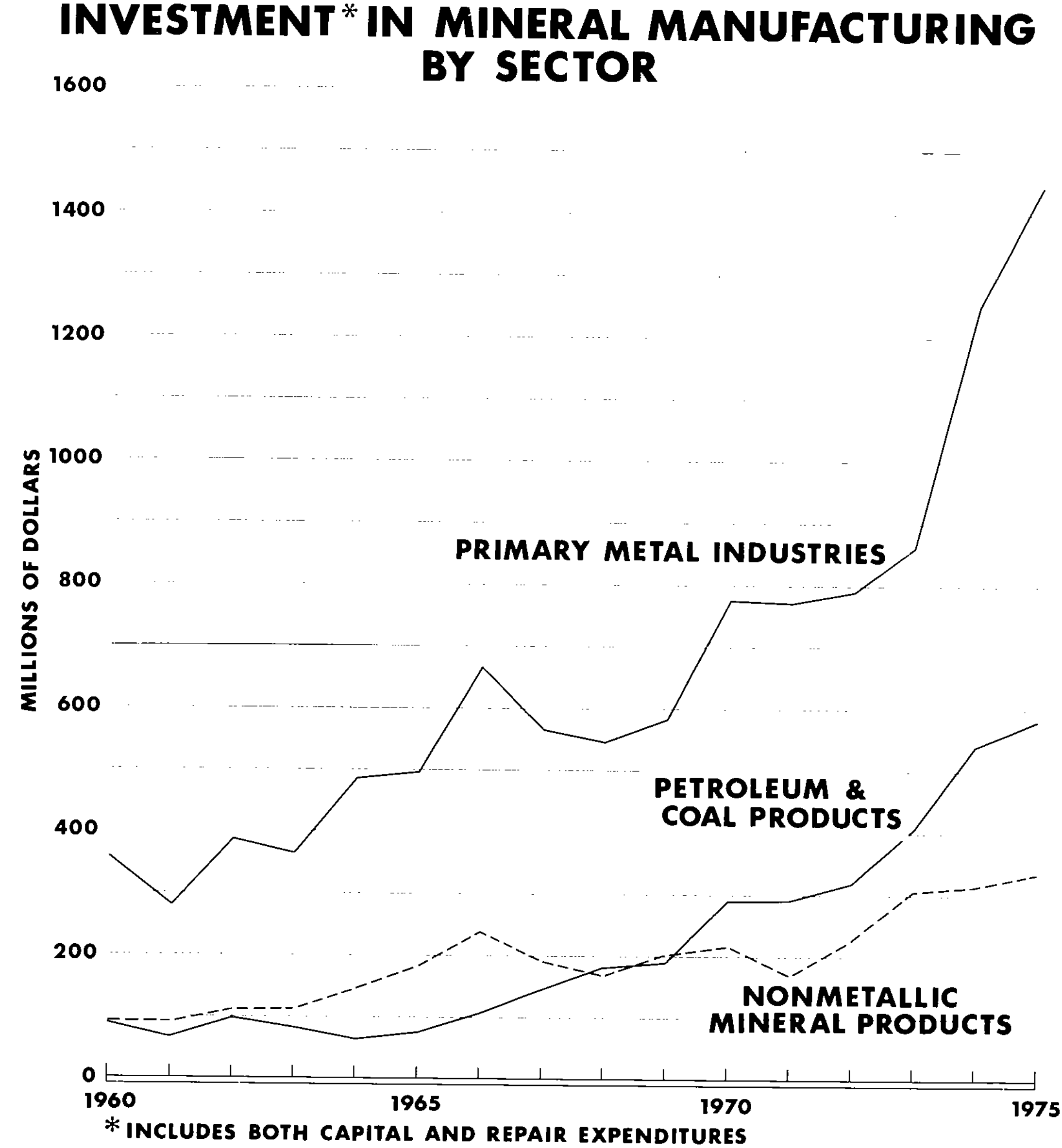


Figure 14

The mineral industry claims that recent increases in taxes, particularly those of some of the provinces, have reduced profits to a level where future operations or expansions are threatened. The industry also claims that the lack of a consistent, co-ordinated mineral policy makes it difficult to plan and operate with any certainty. While it is difficult to establish the validity of such claims, the federal Department of Energy, Mines and Resources is working on the development of a national mineral policy in conjunction with the provincial governments.

Canada will face increased world competition as a major mineral supplier owing to possible supply-demand imbalances and new mineral discoveries and development in many parts of the world. For example, Australia is becoming a major supplier of iron ore and,

RETURN ON INVESTED CAPITAL
AVERAGE 1964 - 1975

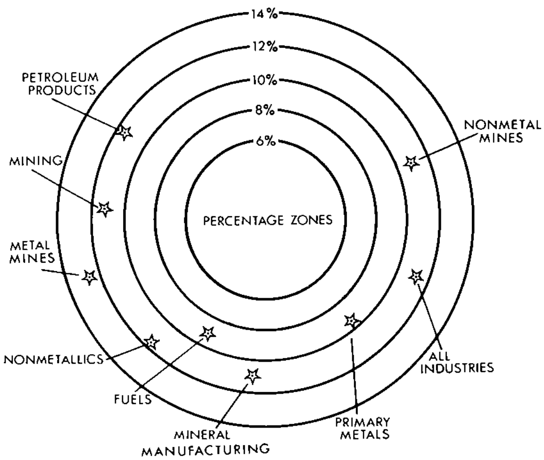


Figure 15

to some extent, nickel; large copper deposits have been discovered and are under development in Africa and the Pacific Rim countries; and large high-grade iron ore deposits are being developed in Brazil. Canada will have to continue its efforts in future years to develop new markets for Canadian products.

Canada acts in a similar fashion to most less-developed countries to the extent that their exports consist mainly of renewable and non-renewable resources. Their mineral exports are usually in direct competition in world markets and yet within this international competition, institutional arrangements exist and are being further developed that reflect the needs and demands of the LDCs but which pose additional problems for countries such as Canada.

The development banks and other international organizations, which provide secure loans on favourable terms to the LDCs and for investment in LDC projects, are being strengthened and expanded. Such loans provide an inducement for industry from all nations to invest in LDC mineral projects. An increasing number of the major industrial nations are providing secure markets for many LDC products. For example, the Lomé agreement between the EEC and the LDCs includes an income guarantee for certain LDC commodity exports to the EEC. Countries such as Canada and Australia will have to negotiate in world fora such as the United Nations to ensure that their mineral projects receive equitable treatment both as to possible financing from international organizations and to ensure the access of their mineral products to international markets.

The 1973-74 oil crisis and political instability in certain parts of the world have caused industrial nations to value secure sources of supply for their raw material imports and multinationals to assess the political stability of a nation before investing in a mineral project in that country. Such factors should work to the advantage of Canadian developments and mineral exports. Also, several countries, notably the United States and Japan, have indicated that they will increase their stockpiles of certain crude materials. This may increase the short-term demand for Canadian mineral exports.

The Canadian mineral industry can expect some growth in output over the next several years both in exports to the recovering international economy and to the Canadian economy. However, the expansion will be below the overall trend prevailing in the last two decades. Canadian mineral policy will have to be developed to maintain and foster a healthy competitive private industry in Canada in order to maintain existing international markets and to develop new markets for Canadian output.

Regional Review

THOMAS W. VERITY

The mineral industry, which includes exploration, development, mining, processing, and services related to mineral production, is a major source of employment and generator of wealth in many regions of Canada. Without the industry, mineral resource regions, if not entire provinces, would be economically stagnant and unable to provide employment for large portions of their population. In recognition of that regional importance, this article reviews some of the more significant regional issues, programs, and events in the mineral industry in 1975.

Exploration and development

Regional levels of exploration expenditure reflect general economic conditions, government policy, and the potential for mineral development. In 1975, the controversy over government mineral policy and taxation and their effects on exploration was a prime issue in several provinces, particularly in British Columbia, Saskatchewan and Manitoba.

Statistical information on exploration and development expenditure in 1975 for industrial and metallic minerals is not available. Data for 1973 and 1974, released in September 1975 by Statistics Canada, are contained in Figure 1.

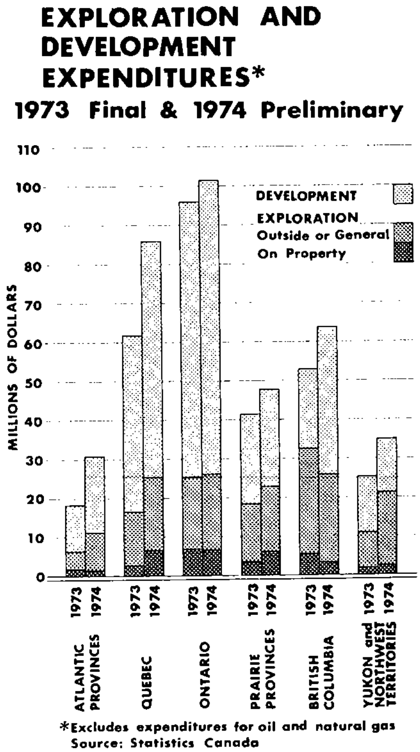


Figure 1

Federal-provincial mineral development programs

Since 1970, the federal government has entered into mineral development programs with several provinces with the objective of stimulating mineral exploration, development or further processing in areas having development potential. Most of these are slow-growth areas in need of more employment and economic diversification. The Department of Regional Economic Expansion (DREE), together with the Department of Energy, Mines and Resources (EMR), co-operates with the provincial governments in the implementation of these programs. Outputs of the programs are made available to the public, thereby providing incentives to the private sector to increase local mineral exploration and production activity.

Alberta. The need to develop a viable iron ore deposit in the prairie region, as a result of expanding steel production in the area, prompted the federal and Alberta governments in 1974 to undertake new investigations of the extensive Clear Hills iron deposits of the Peace River area. In a three-year program of metallurgical research, jointly funded by the Alberta government and EMR, research is being undertaken on the mineralogy, beneficiation and reduction possibilities of the Clear Hills iron-bearing deposits. Tests are being carried out by the Alberta Research Council in Edmonton and by EMR in Ottawa at the Canada Centre for Mining and Energy Technology (CANMET). While the Clear Hills iron is not yet "ore" because of beneficiation problems and phosphorus content, the current research program should clarify the constraints to development of the deposits. Previous research and testing, since the late-1950s, has failed to resolve the beneficiation and metallurgical problems associated with the material.

Saskatchewan. A mineral development program in northern Saskatchewan was begun in 1974 and will continue until 1978. Funded federally by EMR and DREE, with an equal share by the Saskatchewan government, the program provides for resource planning, base metal exploration in the La Ronge-Wollaston areas, iron ore exploration in the southern

Precambrian area, uranium exploration, industrial mineral evaluation in the northern fringe of the sedimentary basin, and reconnaissance geoscience surveys consisting of geological mapping, Quaternary geology and regional geochemical work all in the Precambrian area. Progress was made on all projects during 1975, with work being carried out by the Saskatchewan Department of Mineral Resources in conjunction with EMR and DREE.

Quebec. In the Lac St. Jean-Saguenay-Chibougamau area and in northwestern Quebec, two mineral development programs have been carried out since 1971, funded under the Agricultural and Rural Development Act (ARDA). These have consisted of access road construction, geophysical surveys (air and ground), geochemical surveys, geological mapping and research, and metallurgical research. Release of survey results to the public, combined with improved road access, has stimulated exploration activity considerably in these areas. The discovery of new base metal deposits – such as those made by Iso Mines Limited, Copperfields Mining Corporation, Selco Mining Corporation Limited, Phelps Dodge Corporation of Canada, Limited and New Insco Mines Ltd. – reflect the potential of the areas and the value of public and private exploration endeavour.

In eastern Quebec, a program begun in 1971 under the Fund for Rural Economic Development (FRED) ends in 1976. The agreement provided for access road construction, geological, geochemical, and geophysical surveys, and investigation of specific mineral development opportunities. Most of this activity has centred on the Gaspé peninsula, although some attention was given to salt deposits on the Magdalen Islands.

The Quebec Department of Natural Resources carried out much of the work involved, with the technical co-operation of EMR and federal funding through DREE. Because of positive results, a continuation of these joint-support programs can be expected and both levels of government are currently negotiating a new mineral agreement to carry on the work done under the previous ARDA and FRED programs.

New Brunswick. One of the first federal-provincial mineral programs was implemented in New Brunswick. The original agreement, to accelerate the province's mineral reconnaissance work, was signed on August 31, 1970. The agreement was extended in 1973 and in early 1975 and is due to terminate in September 1976. The cost, nearly $3.9 million, will have been funded almost entirely by DREE.

Under this agreement, extensive detailed geological mapping has been done in northern New Brunswick, starting in the Bathurst-Newcastle area and extending to the west, and in southern New Brunswick, originally in the Caledonia Mountain area but also extending across the province to the west. Preliminary maps have been published, and reports are being prepared. Projects have also been carried out on several mineral commodities. Diamond drilling for salt to the west and southwest of Sussex intersected beds of potash; two companies are conducting exploration and development programs as a result. An inventory of sand and gravel deposits was carried out in the outlying areas of Moncton and Saint John. A project to promote the study of improved and further processing led to two such studies and the first process development work to be carried out by the provincial government.

The design of a new mineral development program, to be jointly funded by Canada and the province over a five-year period, is virtually complete. Projects will be broadly subdivided under the identification of development opportunities and the promotion of such opportunities. They will include: an extensive drilling program to evaluate the province's coal resources; studies based on specific commodities such as limestone, construction raw materials, and various metals; detailed geological mapping in west-central New Brunswick; and a continuation of processing studies, particularly in base metal recoveries and in the reduction of sulphur in coal. The program will take effect under a subsidiary agreement to the General Development Agreement between Canada and New Brunswick.

Nova Scotia. Nova Scotia is in the second year of a five-year Mineral Development Subsidiary Agreement having a total estimated cost of $6.3 million, jointly funded by Canada and the province. An inventory of mineral resources is being conducted; surveys are being carried out on various industrial minerals, sand and gravel deposits in key areas, and oil shale deposits; various carboniferous basins are being systematically drilled for coal seams; and combined geological and geochemical studies are being done in the former gold mining area along the eastern shore of mainland Nova Scotia, in Cape Breton, in the Antigonish and Cobequid Highlands, in the Windsor Group carbonates, and generally on metallogenesis and the structural and metamorphic geology of the province.

Newfoundland. An agreement between Canada and Newfoundland to carry out a Mineral Exploration and Evaluation Program was signed on September 3, 1971. The $2.7 million cost has been borne entirely by the federal government, equally shared by DREE and EMR. The agreement will terminate on March 31, 1976.

The province has carried out a wide variety of work under this program. An inventory of its mineral resources was made; studies under a mineral development planning project have led to important changes in mineral land tenure, a royal commission on mineral revenue, and a new mineral act; mineral evaluation studies were carried out on limestone and dolomite, silica, barite and celestite, clay and peat moss; some geological mapping was done in parts of Labrador; and geochemical surveys were conducted in the lower Paleozoic carbonate belt in western Newfoundland, including the Port au Port area, in the Burlington Peninsula, in the carboniferous basin in the southwest, and in the Avalon Peninsula.

A new mineral development program has been designed for the evaluation of mineral potential with plans for extensive detailed geological mapping in many parts of insular Newfoundland and Labrador and for geochemical and geophysical surveys. The program will also have a planning and development component aimed at specific development opportunities through policy evaluation and the technical and economic assessment of deposits. The program will be a subsidiary agreement under the Canada-Newfoundland General Development Agreement, jointly funded by Canada and the province.

Provincial mineral developments

The value of mineral production in 1975 declined from 1974 levels in Ontario, Quebec and the Northwest Territories. Alberta was again the leading mineral-producing province accounting for 44.8 per cent of the total value of Canadian production which increased 14.5 per cent to $13,402.6 million. Table 1 shows the rank of each province and territory in its contribution to the total value of Canadian mineral production for selected years including 1975. Table 2 compares the value of production of major minerals and mineral groupings by province and measures the change in 1975 production over 1974 values.

British Columbia. The British Columbia mining scene in 1975 was dominated by slumping world commodity markets and industry charges of excessive provincial and federal taxation. Industry opposition continued to be focussed against the Mineral Royalties Act and Mineral Land Assessment Act. On December 22, the province's new Mines Minister recommended the abolition of provincial royalties on copper and other minerals.

A curtailment of copper production was announced early in 1975 by Placer Development Limited, Lornex Mining Corporation Ltd., and Bethlehem Copper Corporation.

Consolidated Churchill Copper Corporation Ltd. closed the Churchill copper mine. Depleted reserves forced Reeves MacDonald Mines Limited to close the Annex lead-zinc mine. In July, Cominco Ltd. suspended operations indefinitely at its Pinchi Lake mercury mine and refinery. At Trail, Cominco shut down its lead-zinc facility during August for maintenance and inventory control. Also in August, Dusty Mac Mines Ltd. began production of gold ore at Okanagan Falls. Processing will be carried out by Dankoe Mines Ltd. at Keremeos.

A British Columbia Hydro and Power Authority task force recommended that future electrical energy be obtained from coal. It was recommended that the first major project should be at Hat Creek, 70 miles west of Kamloops, utilizing lignite deposits.

Yukon and Northwest Territories. At least 76 mining exploration companies were reported working on 96 properties in the Northwest Territories during the year. The outstanding development in 1975 was the announcement by Texasgulf Inc. of a new discovery at Izok Lake about 120 miles west of the Hackett River

(text continued on page 20)

Table 1. Contribution by provinces and territories to Canada's total value of mineral production, selected years, 1955-75

	1955	1965	1970	1974	1975p
			(per cent)		
Alberta	18.2	20.5	24.4	38.6	44.8
Ontario	32.5	26.8	27.8	20.7	17.5
British Columbia	10.6	7.5	8.6	9.9	9.1
Quebec	19.9	19.3	14.0	10.2	8.5
Saskatchewan	4.7	8.8	6.6	6.7	6.2
Newfoundland	3.8	5.6	6.2	3.8	4.2
Manitoba	3.5	4.9	5.8	4.2	4.0
New Brunswick	0.9	2.2	1.8	1.8	1.9
Yukon Territory	0.8	0.4	1.4	1.5	1.7
Northwest Territories	1.4	2.1	2.4	1.9	1.4
Nova Scotia	3.7	1.9	1.0	0.7	0.7
Prince Edward Island	—	0.02	0.01	0.01	0.01
Total Canada, per cent	100.0	100.0	100.0	100.0	100.0
$ million	1,795.3	3,714.9	5,722.1	11,711.0	13,402.6

p Preliminary; — Nil.

Table 2. Value of leading minerals by provinces and territories in 1975, and percentage change from 1974

	% of Total	% Change from 1974
British Columbia		
Copper	27.7	−31.0
Coal	26.7	+113.1
Petroleum, crude	7.7	−8.0
Zinc	6.7	+37.2
Natural gas	5.7	+15.8
Molybdenum	5.5	+10.7
Asbestos	3.2	+41.6
Sand and gravel	2.9	+0.8
Lead	2.5	+23.4
Cement	2.4	+6.2
Silver	2.2	+1.5
Gold	2.0	−5.4
Iron ore	1.2	+14.4
Metallics	48.1	−17.0
Nonmetallics	4.1	+36.6
Fuels	41.4	+53.4
Structural materials	6.4	−1.3
Total	100.0	+5.9
Yukon Territory		
Zinc	41.6	+56.3
Lead	24.6	+36.6
Asbestos	14.0	+40.5
Silver	12.9	+9.8
Copper	5.1	−25.6
Gold	1.8	+3.2
Metallics	85.9	+32.4
Nonmetallics	14.0	+40.5
Fuels	0.1	+25.8
Structural materials	—	—
Total	100.0	+33.4
Northwest Territories		
Zinc	58.1	−16.8
Lead	16.3	−11.7
Gold	16.2	+7.3
Silver	5.2	−44.4
Petroleum, crude	2.2	+33.9
Natural gas	1.8	−37.7
Copper	0.2	−58.3
Metallics	95.9	−15.2
Nonmetallics	—	—
Fuels	4.1	−11.6
Structural materials	—	—
Total	100.0	−15.1
Alberta		
Petroleum, crude	54.2	+9.0
Natural gas	27.3	+154.2
Natural gas byproducts	12.5	+17.8
Coal	3.1	+66.6
Elemental sulphur	1.5	+29.7
Sand and gravel	0.7	+29.8
Metallics	—	—
Nonmetallics	1.6	+30.2
Fuels	97.1	+33.2
Structural materials	1.3	+12.9
Total	100.0	+32.8
Saskatchewan		
Petroleum, crude	47.2	−2.0
Potash	42.0	+12.3
Sodium sulphate	2.5	+65.6
Copper	1.3	−20.7
Sand and gravel	1.2	+0.8
Natural gas	1.1	+5.0
Coal	1.1	+7.0
Salt	0.8	+30.5
Cement	0.7	−9.6
Natural gas byproducts	0.7	−5.2
Metallics	2.2	−16.7
Nonmetallics	45.4	+14.5
Fuels	50.1	−4.1
Structural materials	2.3	−1.7
Total	100.0	+4.6
Manitoba		
Nickel	55.0	+32.0
Copper	16.9	−25.8
Zinc	10.3	+14.0
Petroleum, crude	5.9	+16.5
Sand and gravel	2.5	+12.3
Cement	2.0	−44.0
Gold	1.4	−7.8
Silver	0.8	−23.4
Tantalum	0.6	−8.8
Cobalt	0.4	+8.5
Metallics	85.9	+10.7
Nonmetallics	0.7	+3.0
Fuels	5.9	+16.5
Structural materials	7.5	−4.4
Total	100.0	+9.7
Ontario		
Nickel	34.9	+8.8
Copper	15.9	−23.1
Zinc	11.9	−16.9
Iron ore	9.2	+18.8
Gold	5.5	+2.7
Cement	4.0	−11.8
Sand and gravel	4.0	+8.0
Silver	2.8	−20.7
Stone	2.7	+1.8
Platinum	2.6	+0.7
Clay	1.7	+0.6

Table 2 (concl'd)

	% of Total	% Change from 1974
Ontario (concl'd.)		
Salt	1.6	−7.9
Metallics	83.9	−4.2
Nonmetallics	2.6	−4.8
Fuels	0.5	+52.8
Structural materials	13.0	−1.6
Total	100.0	−3.7
Quebec		
Iron ore	18.2	+30.7
Asbestos	15.5	−24.7
Copper	14.5	−32.9
Zinc	8.6	+1.8
Cement	7.9	+8.8
Stone	7.4	+7.4
Gold	6.7	+12.2
Iron remelt	6.6	+6.0
Titanium dioxide	4.8	+6.1
Sand and gravel	2.8	+35.0
Lime	1.4	+2.3
Silver	1.3	+6.7
Metallics	57.5	−2.2
Nonmetallics	22.0	−18.3
Fuels	—	−70.4
Structural materials	20.5	+9.7
Total	100.0	−4.2
New Brunswick		
Zinc	60.6	+32.2
Lead	10.1	+16.1
Silver	8.6	+4.7
Copper	6.7	−13.9
Coal	2.8	+31.8
Stone	2.1	−9.3
Sand and gravel	1.8	−19.0
Metallics	88.3	+20.5
Nonmetallics	2.2	+0.5
Fuels	2.9	+31.5
Structural materials	6.6	−8.8
Total	100.0	+17.7
Nova Scotia		
Coal	49.2	+94.1
Sand and gravel	12.9	−22.8
Gypsum	12.9	−19.4
Salt	12.8	+10.5
Stone	4.4	−8.3
Cement	3.5	−23.3
Clay	3.3	+14.0
Barite	0.5	−3.2
Peat	0.4	−4.0

	% of Total	% Change from 1974
Metallics	—	—
Nonmetallics	26.7	−6.6
Fuels	49.2	+94.1
Structural materials	24.1	−16.5
Total	100.0	+20.5
Prince Edward Island		
Sand and gravel	100.0	+5.9
Structural materials	100.0	+5.9
Total	100.0	+5.9
Newfoundland		
Iron ore	85.6	+30.8
Zinc	3.7	+41.6
Asbestos	3.2	+12.6
Copper	1.8	+8.0
Sand and gravel	1.4	−10.5
Fluorspar	1.2	−1.7
Lead	0.8	−29.2
Cement	0.6	−13.8
Metallics	92.7	+29.3
Nonmetallics	4.9	+7.3
Fuels	—	—
Structural materials	2.4	−11.1
Total	100.0	+26.7
Canada		
Petroleum, crude	28.2	+7.3
Natural gas	12.9	+139.0
Nickel	8.3	+13.8
Copper	7.6	−27.5
Iron ore	6.9	+27.5
Zinc	6.7	+3.3
Natural gas byproducts	5.7	+17.5
Coal	4.3	+90.2
Potash	2.6	+12.3
Gold	2.1	+4.7
Asbestos	2.0	−11.6
Cement	2.0	−3.4
Sand and gravel	1.9	+9.2
Silver	1.3	−10.9
Stone	1.3	+1.9
Lead	1.1	+13.0
Metallics	35.9	−0.2
Nonmetallics	6.9	+3.8
Fuels	51.2	+31.8
Structural materials	6.0	+1.7
Total	100.0	+14.4

Source: Statistics Canada.
— Nil.

deposits. At least seven million tons of materials containing about 3 per cent copper and 15 per cent zinc have been estimated along the 1,400 feet of strike length drilled during the year.

Production of silver and copper at the former Eldorado Mining and Refining Port Radium mine on Great Bear Lake will be resumed by Echo Bay Mines Ltd. At Giant Yellowknife Mines Limited, an open-pit operation was started to recover low-grade (0.3 oz./ton) ore. A 1976 start-up for Nanisivik Mines Ltd. on north Baffin Island is on schedule.

In the Yukon Territory, work continued on the Grum zinc-lead deposit, which lies five miles southeast of the Cyprus Anvil Mining Corporation mine. Kerr Addison Mines Limited budgeted $6.25 million for work on this property during 1975.

At Hackett River, Cominco continued the development of deposits on the property of Bathurst Norsemines Ltd. Three zones have been defined with a drill-indicated total of 20 million tons. Overall values of eight per cent combined lead-zinc and nine ounces of silver a ton are reported.

Alberta. A new front for mineral exploration in Alberta has been created in the province's northeast corner. A mild boom in claims acquisition has been reported, resulting mainly from increasing interest in uranium exploration around Lake Athabasca. Several air and ground survey projects have been announced by a number of companies.

Oil exploration in Alberta has passed its tenth consecutive year without a major discovery. Natural gas exploration, however, has achieved additions to reserves, partly because increased prices for gas have encouraged a return to more intensive drilling, with several successful wells being drilled. The discoveries of a new gas field at Rosevear and a shallower field about 360 miles northwest of Edmonton have given a big boost to exploration optimism.

In order to assure the continuance of developments by Syncrude Canada Ltd. on its bituminous sand leases near Fort McMurray, the governments of Canada, Alberta and Ontario will invest $600 million in the project. The 125,000 barrels/day plant is about 25 per cent completed, although costs have soared from the original estimate of $800 million to an estimated $2 billion.

Saskatchewan. Attention was focussed on resource taxation and government participation in 1975. In the petroleum industry, royalties were relaxed to stimulate production and exploration that had declined in the metallic minerals sector, and legislation was passed that will give the province the option to participate in exploration and development joint ventures through the Saskatchewan Mining Development Corporation. A new royalty for uranium, based on production and profits, was proposed by the province to increase revenue from this commodity.

At Rabbit Lake, the Gulf Minerals Canada Limited uranium mine and mill started production in late-1975 and is expected to produce 4.5 million pounds of U_3O_8 annually. Gulf Minerals Canada is planning to spend $10 million over the 1975 to 1977 period to explore for additional uranium reserves in the Rabbit Lake area. Results to date have been encouraging. Amok Ltd. at Cluff Lake has reached the detailed engineering stage for its proposed mine and mill. The company, in partnership with Ontario Hydro, plans an extension of previous exploration northeast of Cluff Lake.

Manitoba. New regulations governing exploration programs in Manitoba were introduced in January 1975. The provincial government may now acquire up to 50 per cent equity in any property upon which exploration work budgeted at $10,000 or more in any one year is to take place. At the same time, present holders of mineral dispositions must, during 1975, convert their holdings to one of three types of permits allowed under the regulations, with the exception of Order in Council leases granted before 1975.

These developments have not affected overall exploration activity in Manitoba, as it is the stated objective of the province to maintain an adequate level of expenditure. This will be ensured through Manitoba Mineral Resources Ltd., a provincial Crown corporation, and a new group, the Exploration Operations Branch of the provincial Department of Mines, Resources, and Environmental Management. Total expenditures on exploration for 1975 were approximately $3.5 million by the province, $830,000 by Manitoba Mineral Resources Ltd. and $3.5 million by the private sector.

Tantalum Mining Corporation of Canada Limited operates Canada's only tantalum producer at Bernic Lake, producing tantalum pentoxide concentrates. It is also Canada's only producer of cesium, which is produced in the form of cesium oxide.

Since the implementation of the new exploration regulations, surface drilling in Manitoba has declined 59 per cent for the second and third quarter of 1975 compared with the corresponding period in 1974; footage was 123,745 for April-September 1974.

Ontario. Minerals contribute approximately 4.2 per cent to Ontario's Gross Provincial Product. The value of mineral production during 1974 was the highest for any year in the history of the province. There was, however, a 3.7 per cent decline in 1975, due mainly to lower prices for many metals, marketing problems and labour unrest. Metallic minerals contributed 84 per cent of mineral production, with nickel and copper totalling approximately 50 per cent.

In 1975, Ontario expanded its Mineral Exploration Assistance Program (MEAP) to include eastern Ontario. The MEAP budget for 1975-76 is $500,000. The program has assisted in bringing two mines into production, Tegren Goldfields Limited (operated by Willroy Mines Limited) at Kirkland Lake and Canadaka Mines Limited at Cobalt. Three other promising prospects — Wilmar Mines Limited at Red Lake, Martin-Bird Gold Mines, Limited near Larder Lake, and Barymin Explorations Limited adjoining the Hollinger Ross mine in Hislop Township — also received assistance.

In the northwestern region, the Ontario government is proceeding with the extension of a road north of Red Lake to North Spirit Lake and east of Pickle Lake, with improvements to be made to communications in remote areas of the Red Lake and Patricia mining divisions. Expansion of the NorOntair local air services is planned and should be in operation by 1977. In the north-central region, a new bulk terminal scheduled to open late in 1976 is being built by Thunder Bay Terminals Limited to transfer coal from Western Canada. In southern Ontario, a new precious metal refinery is being constructed at Brampton by Johnson Matthey & Mallory Limited, Toronto.

Quebec. The value of Quebec's mineral production contributes between three and four per cent to the Gross Provincial Product. In 1975, this value was $1,142.5 million.

Northwestern Quebec was the most active mineral exploration region, mainly for gold and zinc. The work done by Bras d'Or Mines Ltd. on a gold prospect on the Bourlamaque batholith northeast of Val d'Or renewed interest in this geological structure, so far largely neglected by prospectors. Belmoral Mines Ltd. staked 305 claims and optioned 100 more around the Bras d'Or property.

New Brunswick. The value of New Brunswick's mineral production contributed between seven and eight per cent to the Gross Provincial Product, or $251.4 million in 1975. About 88 per cent of the value of mineral production comes from metallic minerals. Zinc is the principal metal, representing about 61 per cent of the total for metals. New Brunswick is second only to Ontario in the value of zinc production in Canada. Structural materials are the second most important source of mineral wealth, contributing about seven per cent of the total, while nonmetallics and fuels represent about two per cent each.

The province's base metal mines are in the Bathurst-Newcastle area. Operating mines in 1974-75 included those of Brunswick Mining and Smelting Corporation Limited and Nigadoo River Mines Limited in the Bathurst area, and Heath Steele Mines Limited near Newcastle.

A new base metal discovery was reported in July 1975 in the Nine Mile Brook area, approximately 12 miles southwest of the Brunswick No. 12 mine. Over 400 claims were staked in the area, and several exploration companies were carrying out diamond drilling operations late in the year.

Consolidated Durham Mines & Resources Limited operates an antimony mine at Lake George, 27 miles southwest of Fredericton. Ore reserves had dropped to 150,000 tons by the end of 1974, but a diamond drilling campaign in 1975 has indicated a total of 500,000 tons of ore, grading 5.1 per cent antimony. This will substantially increase the operating life of the mine. In October 1975, management was considering the construction of a $7 million smelter-refinery complex to produce antimony oxide at the mine site.

Nova Scotia. Mineral production value accounts for two to three per cent of the Gross Provincial Product of Nova Scotia. Coal production accounted for 49.2 per cent of total mineral production in 1975, and its value increased 94.1 per cent from that of 1974.

Salt and gypsum are the two major industrial minerals produced in Nova Scotia. The value of salt production increased 10.5 per cent and that of gypsum declined by almost 20 per cent from 1974. At Pugwash, The Canadian Rock Salt Company Limited undertook a $4 million expansion program to increase its production capacity by 30 to 40 per cent.

Celestite is mined at Loch Lomand, Cape Breton Island by Kaiser Celestite Mining Limited. The concentrate from this operation is trucked 35 miles for processing in the Kaiser Strontium Products Limited plant at Point Edward.

Little progress was made during the year in further assessing the lead-zinc deposit at Gays River on property held by Cuvier Mines Ltd. Some delay was encountered in obtaining a permit for underground exploration. In November, Imperial Oil Limited and Cuvier announced their intention to proceed immediately with underground exploration of the deposit.

Prince Edward Island. Sand and gravel are the only mineral commodities produced in Prince Edward Island. In value terms, this production represents only 0.35 per cent of the Gross Provincial Product. The industry provides employment for about 55 persons, mostly on a seasonal basis. In 1975, the value of sand and gravel production was $1.54 million, an increase of 5.9 per cent from 1974.

Newfoundland. The new zinc mine of Tecam Limited started operations in August. Situated near Daniel's Harbour in western Newfoundland, the mine is owned by Teck Corporation Limited (64 per cent) and Amax Zinc (Newfoundland) Ltd. (36 per cent).

Labour productivity

The labour shortage in the mining industry became progressively more severe throughout 1973 and the first nine months of 1974, then began to ease in the last quarter of 1974. This easing trend continued through 1975, with the exception of the Prairie Provinces where reported vacancies remained high. Nevertheless, many mines continued to experience difficulty in attracting an adequate labour supply and the vacancy rate in the industry remained at twice the "all-industry" average. It is virtually certain that there will be a recurrence of severe labour shortages during the next upturn in demand because historical trends, which became apparent in recent years, will be reinforced by demographic factors.

Reduced labour productivity in the mining industry is sometimes associated with declines in mine production. Other factors are probably of greater consequence, but reduced productivity, measured in terms of dollars output per man-hour worked, in the first nine months of 1975 in mines, quarries and oil wells, is indicated by statistics that show an eight per cent lower value of production but only three per cent lower employment compared with a year earlier. A further increase in unit labour costs during the year was the result of higher earnings, which in July 1975 were 18.3 per cent higher than in July 1974. The rise in incomes was most pronounced in the Atlantic region and least pronounced in British Columbia. These different rates of increase in earnings brought all regions closer to the national average, which was $277.73 a week in July 1975.

Processing developments

Since World War II, a tremendous increase in world demand for minerals brought about the rapid development of mining in Canada. However, an increasing proportion of Canadian mineral output has been exported with a minimum amount of processing. While Canada enjoys a comparative advantage in mining, it is less favourably placed in mining manufacturing. A policy of expanding mining, with some expansion of processing, has benefited Canada enormously in the past but, as the Canadian economy matures, mineral processing assumes increasing importance. Accordingly, governments at both the provincial and federal levels are now placing much greater emphasis on mineral (and other resource) processing and manufacturing as an industrial objective.

In 1975, government policies were directed toward specific potential processing opportunities. There were relatively few changes in legislation or regulations to realize more domestic processing in general.

Priorities among commodities differ among provinces. In British Columbia, emphasis is currently on copper and steel. Following the publication of a government-sponsored study on copper processing and a provincial offer of financial assistance, Afton Mines Ltd. announced plans for a small copper smelter near Kamloops. The province continued to investigate, with Japanese interests, the feasibility of building a large primary steel plant on the west coast.

In the Yukon Territory, lead and zinc are of primary interest but a consultant's study released late in 1975 indicated that smelting profitability in the Yukon would be too low to attract private industry.

In 1974, the federal and Saskatchewan governments entered into a five-year steel agreement to develop and expand steelmaking and related industries at Regina. An essential part of the agreement is to establish a direct reduction mill for the production of iron units, augmenting normal supplies of scrap. Also included in the agreement is an iron ore exploration program centred on known deposits at Kelsey Lake, Saskatchewan. When completed, the iron and steel complex could have a direct employment impact of approximately 1,900 jobs in Saskatchewan, with secondary expansion in the steel fabricating industries at other Prairie centres.

In Ontario, in response to relatively generous provincial taxation provisions, Texasgulf Inc. plans to build a new copper smelter and refinery at Timmins which will use a continuous smelting process developed by Mitsubishi in Japan. This plant apparently will have sufficient capacity to handle substantial tonnages of copper in addition to its own mine output, raising the possibility of excess smelting capacity in central Canada. The International Nickel Company of Canada, Limited, also partly in response to tax provisions, will build a new nickel rolling mill in the Sudbury area.

In Quebec, the main emphasis is on new steel production, although the province is also giving consideration to more aluminum smelting, the processing of asbestos, and other energy-intensive processing opportunities to use excess James Bay hydroelectric power.

In Eastern Canada, Nova Scotia has been progressing with its plans for the development of a major international steel complex with significant Canadian participation. The federal government through the Department of Regional Economic Expansion has conducted and continues to conduct studies to determine the economic viability of various regional steel developments. The Atlantic region exports large quantities of zinc concentrates and New Brunswick, Nova Scotia, and Newfoundland have expressed interest in zinc smelting. Newfoundland is also investigating other types of mineral processing, including aluminum smelting, to use electric power from the future Gull Island power project.

Services related to mineral production

Transportation policy. Crude and fabricated mineral products account for approximately 54 per cent of the tonnage carried on Canadian railways and over 60 per cent of the tonnage loaded for international seaborne transport at Canadian ports. The federal government's current review of transportation policy is of considerable interest to the Canadian mineral industry.

A policy paper was released by the Minister of Transport in June 1975 under the title *Transportation Policy — A Framework for Transportation in Canada.* It concludes that transport policy must take greater account than does the present National Transportation Act of the variety of services and varying degrees of competition that exist in Canada. Also, decisions to expand the northern transportation system must be based on national considerations as well as on regional and provincial development aspirations. While spare capacity exists in much of the Canadian freight system, some parts, particularly in western Canada, are nearing their capacity limits, and investment required to meet transport demands will increase substantially over the next ten to fifteen years.

Rail and road projects in northwest Canada will provide new transportation links for mineral development. In northern British Columbia, the British Columbia Railway is being extended from Fort St. James to Dease Lake. This extension, financed by the federal and provincial governments, is scheduled for completion in 1979. Road construction under the federal-provincial Western Northlands Program continued on the Stewart Highway and will connect Stewart, British Columbia and Watson Lake, Yukon Territory. When extended southward to the Prince George-Prince Rupert Highway, this trunk highway will provide a second road link for heavy traffic between central British Columbia and the Yukon. Construction continued on the federally-financed Carcross-Skagway Highway, with completion scheduled for 1978-79.

In the Yukon Territory, the Dempster Highway was extended to Eagle River Crossing in 1975. When subgrade is completed in 1979, this highway will extend 417 miles from Dawson to the Mackenzie Highway near Arctic Red River, Northwest Territories. The federal government also plans to upgrade the Canol Road, running northeast from Ross River to the mineral-rich Selwyn mountains, to secondary trunk road standard.

Plans were announced to build a 28,000 ton Arctic class ice-breaking bulk carrier, with initial service scheduled for the 1977-78 navigation season. The carrier will be operated by a consortium owned 51 per cent by the federal government and 49 per cent by three private companies led by Federal Commerce and Navigation Co. Ltd. The vessel is designed to carry mineral concentrates from the Arctic and large-diameter pipe to the Arctic for transmission of oil and gas.

be liable for the greater of an annual royalty of two per cent of net smelter returns or 15 per cent of all net income derived from a mining operation.

Quebec. The April 17, 1975 Budget Speech announced several changes, all effective April 1, 1975, to the Mining Duties Act which levies a mining tax on mining profits derived in Quebec.

The mining tax rates were adjusted from significantly higher interim rates which had applied for the period of April 1, 1974 to March 31, 1975.

Under the new rate structure, the first $150,000 of mining profits will be exempt from tax. The first $3,000,000 of taxable income will be subject to a rate of 15 per cent, the next $7,000,000 to 20 per cent, the next $10,000,000 to 25 per cent, and any profits in excess of $20,150,000 will be taxed at 30 per cent.

A three-year carry-forward of losses will be permitted as well as a three-year averaging of incomes in order to alleviate the effects that short-term price fluctuations would have on mining duties.

The annual capital cost allowance for mining and processing assets was increased from 15 per cent to 30 per cent.

The deduction of exploration and development expenses incurred in the province was continued to the extent of income. An exploration allowance was provided which allows companies to claim an additional deduction in computing their mining profits of $1 for each $3 of exploration expenditures incurred in Quebec.

An investment allowance provides the same type of additional deduction as for exploration for new expenditures made on concentrating, smelting and refining facilities, including such assets used for contract processing.

The processing allowance was continued at eight per cent of the cost of assets used for concentrating, but it was raised to 15 per cent for smelting and refining. The 15 per cent rate can also apply to concentrating assets if the company further processes its concentrates in Quebec. A minimum and maximum of 15 per cent and 65 per cent, respectively, of the mining profits remaining before the processing allowance was applied were continued.

Manitoba. In July, Manitoba introduced its new Metallic Minerals Royalty Act to become effective January 1, 1975. The new Act provides for a "basic" royalty and an "incremental" royalty, both related to an annual "profit base". The basic royalty is 15 per cent of the profit base for a year while the incremental royalty is 35 per cent of any profits in excess of the profit base.

The profit base for a year is calculated under interdependent formulae which take into consideration the undepreciated balance of investment at the start of the year adjusted for inflation during the year, new investment during the year, depreciation for the year, and disposals of depreciable assets during the year. In this manner, an investment base is derived for each year to which an investment base factor (18 per cent) is applied to obtain the profit base. The total profit to be taxed is then calculated under provisions which are similar in many respects to those of the former Mining Royalty and Tax Act. The profit base portion of the total profits is taxed at 15 per cent and the excess of the total profit over the profit base is taxed at 35 per cent.

Other regions. The other provinces, many of which had made mining tax and royalty changes in 1974, did not make any further adjustments in 1975. The mining tax structures of the Yukon Territory and the Northwest Territories have been under study by the federal Department of Indian and Northern Affairs for several years.

Lightweight Aggregates

D.H. STONEHOUSE

Sand and gravel have been the traditional aggregates used in concrete and concrete products. With the advance of concrete technology the need for clean, sharp aggregate with a designed particle size distribution was emphasized and the use of crushed stone aggregate as well as crushed, screened and washed gravel became standard procedure. The methods of mixing, transporting, placing and curing of concrete are the subjects of on-going studies and research in conjunction with the use of various types of cement as the binding media. Until the mid-1940's, comparatively little attention was paid to designing concrete products to meet a specific requirement other than a certain predetermined strength and setting time. At that time increased housing demand accentuated the need for prefabricated structures. Techniques of construction were developed using structural sections and panels of much lighter unit weight, with no sacrifice of strength, by utilizing lightweight aggregates which also incorporated the added advantage of insulation from heat, fire, sound and moisture. The use of lightweight concrete in commercial and institutional projects has facilitated the construction of taller buildings and the use of longer clear spans. Normal aggregates are becoming scarce in many consuming regions to the extent that it may be necessary to utilize lightweight aggregates in these particular areas for reasons other than the derived physical benefits.

Four categories generally used to classify the lightweight aggregates combine elements of source, processing methods and end-use. Natural lightweight aggregates include materials such as pumice, scoria, volcanic cinders and tuff. Manufactured lightweights are bloated or expanded products obtained by heating certain clays, shales, and slates. Ultra-lightweights are made from natural mineral ores, such as perlite and vermiculite, which are expanded or exfoliated by the application of heat and used mainly as plaster aggregate or as loose insulation. Fly ash, which is obtained from the combustion of coal and coke, and slag, which is obtained from metallurgical processes, are classed as byproduct aggregates.

All types are used in Canada, but only expanded clays, shale and slag are produced from materials of domestic origin. Vermiculite is imported mainly from Montana, U.S.A., although a small amount is brought in from the Union of South Africa. Perlite is imported mainly from New Mexico and Colorado, and pumice is imported from Oregon and from Greece.

Canadian industry and developments

Most processed lightweight aggregate is utilized in the construction industry, either as loose insulating material or as aggregate in the manufacture of lightweight concrete units. The scope of such applications has not yet been fully investigated. Rising energy costs have increased the optimum quantities of insulation in new building construction and have resulted as well in the addition of more insulating materials in older structures. This trend will undoubtedly continue and should offer expanded markets for the lightweight aggregates. The advantages of location and cost enjoyed by the normal heavy aggregates are becoming less of a factor as land-use conflicts are more evident and transportation costs continue to increase.

Perlite. Perlite is a variety of obsidian or glassy volcanic rock that contains 2 to 6 per cent of chemically combined water. When the crushed rock is heated rapidly to a suitable temperature it expands to between 4 and 20 times its original volume. Expanded material can be manufactured to weigh as little as 2 to 4 pounds a cubic foot, with attention being given to preblending of feed to the kiln and retention time in the flame.

In Canada, imported perlite is expanded and used mainly by gypsum products manufacturers in plaster products such as wallboard and drywall, and in fibre-perlite roof insulation board, where its value as a lightweight material is augmented by its fire-resistant qualities. It is also used as a loose insulation and as an insulating medium in concrete products. Perlite, vermiculite and expanded shale and clay, are becoming more widely used in agriculture as soil conditioners and fertilizer carriers.

Table 1. Canada, production of lightweight aggregates, 1974-75

	1974		1975	
	cu. yd	$	cu. yd	$
From domestic raw materials				
Expanded clay, shale and slag	804,985	5,272,821	740,637	5,421,956
From imported raw materials				
Expanded perlite and exfoliated vermiculite	913,404	7,418,160	842,770	11,458,543
Pumice	57,850	544,732	53,333	485,997
Total	1,776,239	13,235,713	1,636,740	17,366,496

Source: Company data.

Imports of crude perlite for consumption in Canada are from New Mexico and Colorado deposits, worked by such companies as Johns-Manville Corporation, United States Gypsum Company, United Perlite Corp. and Grefco Inc. In 1975, eight companies at 10 locations in Canada reported production of expanded perlite.

Perlite occurs in British Columbia, but no commercial deposits have as yet been located.

Pumice. Pumice is a cellular, glassy lava, the product of explosive volcanism, usually found near geologically-recent or active volcanoes. It is normally found as a loosely compacted mass composed of pieces ranging in size from large lumps to small particles. It is not the lightest of the lightweight aggregates, but when utilized as a concrete aggregate, particularly for the manufacture of concrete blocks, it exhibits strength, density and insulating values that have made it a preferred material.

Table 2. Canada consumption of expanded clay and shale

	1973	1974	1975
	(per cent)		
Concrete			
block	67.0	65.6	77.4
precast structural	6.0	4.2	10.9
cast-in-place structural	25.0	24.0	7.0
Minor Uses			
sand blasting, horticulture refractories, insulation brick grog, flexible pavement	2.0	6.2	4.7

Source: Company data.

In Canada, a number of concrete products manufacturers use pumice imported from Greece or from northwestern United States, mainly in the manufacture of concrete blocks. A major use for pumice, as yet unexplored in Canada, has been in highway construction, where lightweight aggregate surfaces have been shown to have exceptional skid resistance.

Pumicite, distinguished from pumice by its finer size range (usually minus 100 mesh), is used in concretes mainly for its pozzolanic qualities. (A pozzolan is a siliceous material possessing no cementitious qualities until finely ground, in which form it will react with calcium hydroxide in the presence of moisture to form insoluble calcium silicates).

Extensive beds of pumicite have been noted in Saskatchewan and in British Columbia.

Vermiculite. The term vermiculite refers to a group of micaceous minerals, hydrous magnesium-aluminum silicates, that exhibit a characteristic lamellar structure and that expand or exfoliate greatly upon being heated rapidly. Mining is normally by open-pit methods; and beneficiation techniques include the use of hammer mills, rod mills, classifiers, screens, dryers and cyclones. Exfoliating is done in oil- or gas-fired, vertical or inclined furnaces, usually close to the consuming facility to obviate the higher costs associated with shipping the much bulkier expanded product. The expansion process has advanced technologically to permit production of various grades of expanded vermiculite as required. The uses to which the product is put depend on its low thermal conductivity, its fire-resistance and, more recently, on its lightweight qualities.

Canadian consumption is mainly as loose insulating material, with smaller amounts being used as aggregate in the manufacture of insulating plaster and concrete. The energy situation will undoubtedly continue to result in increased domestic fuel costs and greater use of insulation in both new construction and older buildings will continue to tax the production capability of manufacturers for some time.

The major producer of vermiculite is the United States. The principal company supplying Canada's imports is W.R. Grace and Company, from operations at Libby, Montana. Canada also imports crude vermiculite from the Republic of South Africa, where Palabora Mining Co. Ltd. is the major producer. At both the Grace and Palabora operations milling limitations have necessitated new mill installations in an effort to keep up with demand. Minor amounts of vermiculite are produced in Argentina, Brazil, India, Kenya and Tanzania.

Vermiculite occurrences have been reported in British Columbia, and a deposit near Perth, Ontario has been investigated but, as yet, no commercial deposits have been developed in Canada.

Table 3. Canada, consumption of expanded perlite

	1973	1974	1975
	(per cent)		
Insulation	92.0	92.0	91.1
Agriculture, horticulture	5.0	5.0	5.2
Other uses			
fillers	3.0	3.0	3.7

Source: Company data.

Clay and Shale. Common clays and shale are used throughout Canada as raw material for the manufacture of lightweight aggregates. Although the Canadian industry began in the 1920s in Ontario, it did not evolve significantly until the 1950s when it grew in support of demands from the construction industry. The raw materials are usually quarried adjacent to the plant sites at which they are expanded. Clays receive little beneficiation other than drying before being introduced to the kiln in which they are heated. Shales are crushed and screened before burning. Eight plants in Canada using a rotary kiln process currently produce lightweight aggregates from clay and shale.

One company produces an aggregate material from slag as a byproduct of a blast furnace operation. In steelmaking, iron ore, coke and limestone flux are melted in a furnace. When the metallurgical process is completed, lime has combined with the silicates and aluminates of the ore and coke and formed a nonmetallic product (slag) which can be subjected to controlled cooling from the molten state to yield a porous, glassy material. Slag has many applications in the construction industry. The statistics relative to expanded slag production are included in those of clay and shale.

Table 4. Canada, consumption of exfoliated vermiculite

	1973	1974	1975
	(per cent)		
Loose insulation	73.0	75.0	77.0
Insulating plaster	3.0	2.2	1.0
Insulating concrete	7.0	3.7	3.9
Agriculture, horticulture	9.0	8.0	8.8
Minor uses			
Fireproofing, underground pipe insulation, barbecue base	8.0	11.1	9.3

Source: Company data.

Although Canada does not produce large amounts of fly ash, the technology of fly-ash processing and utilization is well advanced. The largest single use for fly ash is as a cementitious material where its pozzolanic qualities are utilized. Use of fly ash as a lightweight aggregate could become of increasing importance. International Brick and Tile Ltd. of Edmonton, Alberta, which produces brick using fly ash and bottom ash as raw material, was taken over by Great West Steel Industries Ltd. of Vancouver in 1972. Ontario Hydro produces nearly 450,000 tons of fly ash a year from three coal-fired stations. Experimentation continues towards successful utilization of this material at the Lakeview plant in the production of pozzolan, iron oxide and lightweight pellets. Disposal costs of $2 to $3 a ton add incentive to such programs.

Specifications

There are as yet no Canadian Standards Association (CSA) specifications for the lightweight aggregates. Production and application are based on the American Society for Testing and Materials (ASTM) designations as follows: ASTM Designations C 332-56 T — Lightweight Aggregates for Insulating Concrete; C 330 — Lightweight Aggregates for Structural Concrete; and C 331 — Lightweight Aggregates for Concrete Masonry Units.

Outlook

Demand for all lightweight aggregates will continue to increase as their use in structural concrete and for insulation purposes becomes more popular. In view of increased costs of energy, the amount of insulation which can be economically installed in new housing and, indeed, in older housing, has about doubled during the past few years thereby placing great demand pressure on the suppliers of these materials. The four main lightweight materials — perlite, pumice, vermiculite and expanded clays — are interchangeable for many applications and can, along with some synthetic

Table 5. Lightweight aggregate plants in Canada, 1975

Company	Location	Product
Atlantic Provinces		
Avon Aggregates Ltd.	Minto, N.B.	Expanded shale
Quebec		
F. Hyde & Company, Limited	Montreal	Vermiculite
Laurentide Perlite Inc.	Charlesbourg West	Perlite
Masonite Canada Ltd.	Gatineau	Perlite
Perlite Industries Reg'd.	Ville St-Pierre	Perlite
Vermiculite Insulating Limited	Lachine	Vermiculite
Ontario		
Canadian Gypsum Company, Limited	Hagersville	Perlite
Canadian Johns-Manville Company, Limited	North Bay	Perlite
Domtar Construction Materials Ltd.	Caledonia	Perlite, shale
	Mississauga	Expanded shale
Grace Construction Materials Ltd.	St. Thomas	Vermiculite
	Ajax	Vermiculite
National Slag Limited	Hamilton	Slag
Prairie Provinces		
Cindercrete Products Limited	Regina, Sask.	Expanded clay
Consolidated Concrete Limited	Calgary, Alta.	Expanded shale
Domtar Construction Materials Ltd.	Calgary, Alta.	Perlite
Echo-Lite Aggregate Ltd.	St. Boniface, Man.	Expanded clay
Consolidated Concrete Limited		
Edcon Block Division	Edmonton, Alta.	Expanded clay
Grace Construction Materials Ltd.	Winnipeg, Man.	Vermiculite
Kildonan Concrete Products Ltd.	St. Boniface, Man.	Expanded clay
Northern Perlite & Vermiculite Limited	St. Boniface, Man.	Vermiculite
British Columbia		
Grace Construction Materials Ltd.	Vancouver	Vermiculite
Ocean Construction Supplies Limited	Vancouver	Pumice[1]
Westroc Industries Limited	Vancouver	Perlite

Source: Company data
[1] Pumice is used in concrete block manufacture.

materials, be considered substitutes or alternates for each other.

The United States is the source of most of the lightweight raw materials consumed in Canada, exclusive of clay, shale and slag. The U.S. reserves are sufficient, both for its domestic requirements and for exports to meet Canada's projected needs for many years.

World review

The United States and Greece are the main producers of perlite, with smaller quantities mined in Algeria, Turkey, the Philippines and New Zealand. New Zealand could become a major producer if huge deposits owned by Consolidated Silver Mining Co. are developed for export markets.

The major producers of pumice include the United States, Italy, West Germany and Greece, although production is recorded from other countries. As with other low-cost lightweight material, transportation costs are the main factors in determining the competitiveness of pumice. Prices have not varied greatly in recent years.

The use of fly ash should increase with the added incentives provided by environmental control. Two cement companies in the United States have begun to blend fly ash with portland cement at three plants to produce portland-pozzolan cement for general construction use. Using only about 20 per cent of ash production, industry in North America falls far short of European enterprises, which use as much as 80 per cent of production.

In the United States, W.R. Grace and Company, Zonolite Division is by far the largest producer of vermiculite, with mines in Montana and South Carolina. Through the Palabora Mining Co. Ltd. the Union of South Africa remains the second largest producer.

The unit price has shown a steady but unspectacular rate of increase during the past few years and is likely to continue to do so in pace with a steady increase in demand and inflationary conditions.

Aluminum

M.J. GAUVIN

The softening of demand for aluminum that developed in 1974 worsened in the first quarter of 1975, forcing aluminum producers to sharply cut production rates to bring production more in line with demand. Canadian capacity taken out of production in 1975 was 20 per cent of the total, while United States production cutbacks amounted to 26 per cent of capacity. About 30 per cent of Japanese capacity was idled during the year, but European production cutbacks were almost negligible. Producer inventories continued to rise until the fourth quarter of the year, during which they levelled out and declined slightly. Lagging demand and low profits forced many producers to suspend expansion programs and to postpone new projects.

Canada

No economic deposits of bauxite, the predominant ore of aluminum, are found in Canada. Bauxite is imported for the production of alumina by the Bayer process. Alumina is an aluminum oxide intermediate product which is reduced in an electric furnace to aluminum metal by the Hall-Heroult process. Approximately 4.5 tons* of bauxite are refined to two tons of alumina, which in turn are smelted to obtain one ton of aluminum. The Hall-Heroult process involves high consumption of electric power; from 7 to 8 kWh per pound of aluminum produced. For this reason, Canada's aluminum smelters are advantageously located near large low-cost power sources. Also, because transportation costs are such an important factor in the import of raw materials and export of aluminum, these smelters are all located near ocean shipping ports.

Production

Canadian primary aluminum output decreased to 977, 533 tons in 1975 from 1,125,329 tons in 1974. The two companies, which operate primary aluminum smelters in Canada are the Aluminum Company of Canada, Limited (Alcan), a subsidiary of Alcan Aluminium Limited of Montreal (also referred to as Alcan) and Canadian Reynolds Metals Company, Limited, a subsidiary of Reynolds Metals Company of Richmond, Virginia. Because of the reduced demand, the Canadian primary aluminum industry operated at an average rate of 83 per cent of capacity in 1975 compared with an average rate of 93 per cent of capacity in 1974. Starting in January, a series of production cutbacks by the producers saw the Canadian production rate decreased to 80 per cent of capacity by the end of May, a rate which was maintained to the end of the year. During the first half of the year Alcan shut down a total of 211,000 of annual capacity and Reynolds shut down 27,000 tons of annual capacity.

Some 2,668,331 tons of bauxite were imported from Guinea, Guyana, Sierra Leone, Surinam and elsewhere for the production of alumina at Alcan's refinery at Arvida, Quebec, the only alumina refinery in Canada. It has a capacity of 1,387,000 tons a year and supplies Alcan's four smelters in Quebec. Alcan increased its imports of bauxite from Guinea, where Alcan has a 13.5 per cent interest in the Compagnie des Bauxites de Guinee in partnership with the Government of Guinea and five other aluminum producers.

In 1975, Alcan's five Canadian smelters produced 838,000 tons of primary aluminum compared with an output of 963,000 tons in 1974. Alcan Aluminium Limited, a multi-national company, has wholly- and partially-owned smelters in Japan, Norway, Spain, Great Britain, India, Sweden, Brazil and Australia. In 1975, Alcan's total production, including Canadian production was 2,016,000 tons down from the record 2,174,000 tons produced in 1974.

The Canadian Reynolds Metals Company, Limited operates a smelter at Baie-Comeau, Quebec. Its production in 1975 was 131,700 tons down from the 148,800 tons produced in 1974. Canadian Reynolds obtains most of its alumina from the United States, while Alcan imports alumina mainly from Australia and Jamaica.

Some expansion of Canadian primary smelting capacity was begun by Alcan in 1974. Two expansions

*The short ton of 2,000 pounds is used throughout unless otherwise stated.

in ingot capacity of 25,000 tons each were started at the Arvida and Kitimat smelters but the completion of these new facilities was deferred during 1975 because of adverse market conditions and financial constraints. Alcan plans a progressive rebuilding and eventual expansion of its Canadian smelting capacity by some 300,000 tons, or about 30 per cent, at an estimated capital cost of $1 billion. Part of the expansion would come through modernization of existing facilities and the balance through the construction of additional facilities. The timing of the program will depend on economic factors.

Alcan's wholly owned subsidiary, Alcan Canada Products Limited, is in the final stages of installing a second cold-rolling mill, together with a continuous heat-treating line, at its Kingston works. This $22 million installation will increase Alcan's coiled sheet capacity in Canada to 190,000 tons.

The government of Quebec and National-Southwire Aluminum Company of Hawesville, Kentucky, have been discussing the building of a joint venture aluminum smelter and fabricating plant at St. Augustin, near Quebec City.

Reynolds Aluminum Company of Canada Ltd. has completed a 145,000-square-foot addition to its Cap-de-la-Madeleine, Quebec rolling mill to house additional melting, casting and other manufacturing equipment.

Canadian exports of aluminum, mainly in ingot form but also including further fabricated materials, were 588,148 tons; down substantially from the 806, 817 tons exported in 1974. The value of 1975 exports was $464,219,000 compared with $541,949,000 in 1974, a decrease of 14 per cent.

Table 1. Canada, aluminum production and trade, 1974-75

	1974		1975^p	
	(short tons)	($)	(short tons)	($)
Production	1,125,329	. .	977,553	. .
Imports				
Bauxite ore				
Guinea	972,270	10,344,000	1,259,045	15,064,000
Guyana	1,253,359	10,418,000	904,638	7,659,000
Surinam	349,048	7,830,000	115,104	4,689,000
Sierra Leone	346,146	2,656,000	367,515	3,297,000
United States	34,669	1,913,000	19,216	1,283,000
South Africa	—	—	2,813	41,000
People's Republic of China	37,949	746,000	—	—
Total	2,993,441	33,907,000	2,668,331	32,033,000
Alumina				
Australia	424,571	37,127,000	445,371	49,413,000
United States	224,779	18,641,000	233,143	30,698,000
Jamaica	183,462	12,757,000	86,974	10,220,000
West Germany	102,267	9,141,000	38,932	6,037,000
Guyana	26,220	1,803,000	24,009	1,704,000
Surinam	12,408	821,000	9,792	1,125,000
Other countries	257	117,000	214	433,000
Total	973,964	80,407,000	838,435	99,630,000
Aluminum and aluminum alloy scrap	6,433	2,484,000	8,433	1,326,000
Aluminum paste and aluminum powder	4,347	3,741,000	3,207	3,004,000
Pigs, ingots, shots, slabs, billets, blooms and extruded wire bars	52,856	38,524,000	20,085	17,132,000
Castings	897	2,222,000	1,037	3,216,000
Forgings	777	2,712,000	484	2,272,000
Bars and rods, nes	3,106	4,258,000	1,712	2,451,000
Plates	15,211	13,801,000	5,346	6,490,000
Sheet and strip up to .025 inch thick	32,296	27,484,000	16,189	16,535,000

Table 1. (cont'd)

	1974		1975^p	
	(short tons)	($)	(short tons)	($)
Sheet and strip over .025 inch up to .051 inch thick	10,114	10,966,000	3,634	4,827,000
Sheet and strip over .051 inch up to 1.25 inch thick	19,692	17,880,000	10,599	10,504,000
Sheet over 1.25 inch thick	23,725	18,302,000	20,358	19,247,000
Foil or leaf	1,336	1,964,000	764	1,184,000
Converted aluminum foil	. .	5,635,000	. .	3,755,000
Structural shapes	3,202	7,220,000	1,706	3,740,000
Pipe and tubing	2,204	4,097,000	1,427	3,163,000
Wire and cable excl. insulated	2,265	3,494,000	1,244	2,186,000
Aluminum and aluminum alloy fabricated materials, nes	. .	16,994,000	. .	15,084,000
Total aluminum imports		296,092,000		247,779,000
Exports				
Pigs, ingots, shot, slab, billets, blooms, and extruded wire bars				
United States	415,817	250,903,000	341,143	249,474,000
Japan	80,874	47,593,000	45,100	28,215,000
People's Republic of China	—	—	36,382	24,142,000
Brazil	25,201	15,387,000	19,262	13,878,000
Hong Kong	7,403	4,922,000	13,451	10,287,000
United Kingdom	76,852	52,321,000	12,957	10,118,000
Turkey	9,895	6,674,000	13,480	8,970,000
Netherlands	34,409	19,890,000	9,041	6,133,000
Nigeria	1,314	935,000	7,524	5,787,000
Italy	14,526	9,524,000	6,251	4,528,000
Malaysia	7,104	4,926,000	5,809	4,196,000
Other countries	80,797	51,027,000	50,848	37,439,000
Total	754,192	464,102,000	561,248	403,167,000
Castings and forgings				
United States	1,206	5,463,000	514	5,510,000
France	44	631,000	90	1,029,000
United Kingdom	5	48,000	79	447,000
Netherlands	18	138,000	10	244,000
Other countries	158	243,000	10	264,000
Total	1,431	6,523,000	703	7,494,000
Bars, rods, plates, sheets and circles				
United States	12,840	9,007,000	4,507	4,129,000
Ecuador	403	314,000	633	607,000
Switzerland	226	260,000	406	555,000
United Kingdom	4,350	2,156,000	582	510,000
Jamaica	775	778,000	380	414,000
Portugal	7,058	4,271,000	554	352,000
Spain	2,009	1,195,000	358	348,000
Trinidad-Tobago	1	1,000	285	342,000
South Africa	101	55,000	275	312,000
Venezuela	20	19,000	127	204,000
Other countries	5,969	4,634,000	446	534,000
Total	33,752	22,690,000	8,553	8,307,000

Table 1. (concl'd)

	1974		1975^p	
	(short tons)	($)	(short tons)	($)
Exports (cont'd)				
Foil				
Sweden	—	—	234	377,000
Philippines	—	—	149	182,000
Venezuela	—	—	121	175,000
Italy	—	—	60	104,000
Brazil	125	192,000	20	30,000
Other countries	340	284,000	60	129,000
Total	465	476,000	644	997,000
Fabricated materials, nes				
United States	8,511	7,035,000	6,790	6,872,000
Pakistan	80	69,000	2,765	3,054,000
Iran	1,533	839,000	1,840	1,899,000
Tunisia	27	31,000	1,125	1,437,000
United Kingdom	959	1,738,000	455	889,000
Ecuador	54	100,000	672	542,000
Other countries	5,813	4,511,000	3,353	3,181,000
Total	16,977	14,323,000	17,000	17,874,000
Ores and concentrates				
United States	25,057	3,350,000	20,109	3,254,000
United Kingdom	1,153	196,000	1,212	243,000
France	1,047	192,000	1,430	225,000
Spain	1,438	221,000	1,406	213,000
Italy	1,860	326,000	840	134,000
Sweden	502	113,000	281	45,000
Other countries	2,059	384,000	864	182,000
Total	33,116	4,782,000	26,142	4,296,000
Scrap				
United States	47,466	24,315,000	34,534	17,813,000
Japan	3,773	2,014,000	3,306	1,423,000
West Germany	1,525	753,000	3,027	1,044,000
Spain	3,221	664,000	2,942	523,000
Belgium-Luxembourg	62	20,000	978	481,000
Italy	699	425,000	701	306,000
Netherlands	242	99,000	240	101,000
United Kingdom	184	70,000	197	101,000
Other countries	1,611	693,000	825	292,000
Total	58,783	29,053,000	46,750	22,084,000
Total aluminum exports		541,949,000		464,219,000

Source: Statistics Canada.
^p Preliminary; — Nil; nes Not elsewhere specified; . . Not available.

Consumption

Canadian consumption of aluminum is estimated at 330,000 tons for 1975, a decrease of 16.8 per cent from the 396,603 tons consumed in 1974.

World Review

World production of bauxite was about 80 million tons in 1975, down from 91 million tons the previous year. Australia remained the world's largest producer, producing about the same amount as it did in 1974. Most of the major bauxite producers were forced to reduce production, and the countries with the largest cutbacks were Jamaica, Surinam and Guyana. World production of aluminum declined from 15.3 million tons in 1974 to 14.0 million tons in 1975. Producers of bauxite, alumina and aluminum had stockpiles well in excess of normal levels at the end of the year.

The International Bauxite Association (IBA) now consists of 11 member countries. Australia, Guinea, Guyana, Jamaica, Sierre Leone, Surinam and Yugoslavia were the founding members when the IBA was formed at Conakry, Guinea in March 1974; Haiti, Ghana and the Dominican Republic joined the Association at its meeting in Georgetown, Guyana in November 1974, and Indonesia became a member at the second annual meeting held in Kingston, Jamaica in 1975. The IBA was formed to further the interests of the bauxite-producing nations. The Association intends to develop a uniform pricing policy, linked to the price of ingots, that will take into consideration bauxite grade, transportation, operating costs and the establishment of a floor price for bauxite. The members of the Association have yet to agree on a pricing formula and a minimum floor price for bauxite.

Jamaica, one of the leaders of the IBA, has also set the pace in increasing the returns from bauxite resources. In June, 1974, the government of Jamaica passed its Bauxite Production Levy Act which increased the basic rate of levy for bauxite mines and gave the government the right to acquire equity participation in the mining operations and buy back the lands held by the aluminum companies. The levy is based on the average realized price of aluminum and was set at 7.5 per cent for the fiscal year 1974/75, 8.0 per cent for 1975/76 and 8.5 per cent for 1976/77. A minimum annual tonnage of bauxite to be mined was also set. Prior to the passage of the Act the average levy in Jamaica was about $2.50 a long ton of bauxite. Since then the levy has increased, in the case of Alcan, to over $11 a ton in 1974, to $13.00 a ton in the first quarter of 1975, to $14.51 a ton for the balance of 1975 and is scheduled to increase again in 1976. The bauxite mining companies operating in Jamaica are Alcan Jamaica Ltd., Alcoa Minerals of Jamaica Inc., Reynolds Jamaica Mines Ltd., Kaiser Bauxite Company, Revere Jamaica Alumina Ltd. and Alumina Partners of Jamaica (Alpart). Jamaica has completed negotiations with Kaiser, Reynolds and Revere to acquire 51 per cent of their Jamaican companies, and began negotiations with Alcan in June.

Table 2. Canada, primary aluminum production, trade and consumption, 1966-75

	Production	Imports	Exports	Consumption[1]
	(short tons)			
1966	889,915	16,923	716,382	243,301
1967	963,343	8,176	760,649	217,484
1968	979,171	15,043	862,634	242,390
1969	1,078,717	11,531	886,688	269,027
1970	1,061,020	13,425	839,598	275,743
1971	1,120,951	17,527	890,160	322,081
1972	1,012,132	38,741	770,869	333,550
1973	1,037,859	49,535	771,786[r]	365,728
1974	1,125,329	52,856	754,192	396,602
1975[p]	977,553	20,085	561,248	330,000

Source: Statistics Canada.
[1] Excluding aluminum metal used in the production of secondary aluminum.
[p] Preliminary; [r] Revised; . . Not available.

Among the other IBA member states, the governments of Haiti, Dominican Republic and Guinea reached agreement on new bauxite taxes with the producers in their countries. The government of Guyana completed the nationalization of North American aluminum companies in Guyana when it reached agreement with Alcan on the takeover of Alcan's subsidiary, Sprostens (Guyana) Limited. In July 1971, Guyana nationalized Alcan's The Demerara Bauxite Company Limited and in December 1974. Reynolds Guyana Mines Ltd.

Australia, in spite of the reduced world demand for aluminum, increased its bauxite production and experienced only a small decrease in aluminum production. Shipments of bauxite from the Weipa deposit of Comalco Limited, the largest single bauxite mining operation in the world, decreased slightly to 9.1 million tons. New Zealand Aluminum Smelters Ltd., 50 per cent owned by Comalco, deferred the expansion of its Bluff, New Zealand smelter from 123,000 to 165,000 tons a year until 1976. Comalco is also delaying construction of a 110,000-ton-a-year smelter at Gladstone, Australia for one year and start-up is now scheduled for 1978. Alcoa of Australia Ltd., intends to expand its Pinjarra alumina refinery to 2.2 million tons a year in 1976 from its present capacity of 880,000 tons a year.

Production of bauxite in Guinea increased slightly in 1975 compared with 1974. The leading producer of bauxite in Guinea, Compagnie des Bauxites de Guinee (CBG), mines the Boke deposit and is owned 49 per cent by the government of Guinea and 51 per cent by Halco Mining Company. CGB shipped over 6 million tons of bauxite in 1975 and its ultimate capacity of 9.9 million tons is expected to be reached in 1979. Alcan

Table 3. Canada consumption of aluminum at first processing stage

	1972	1973	1974	1975p
	(short tons)			
Castings				
Sand	1,468	1,799	1,891	
Permanent-mould	13,351	14,930	15,363	
Die	28,120	27,408	23,067	
Other	182	145	3	
Total	43,121	44,282	40,324	. .
Wrought products				
Extrusions including tubing	87,588	102,002	105,976	
Sheet, plate, coil and foil	104,400	129,207	156,221	
Other wrought products (including rod, forgings and slugs)	87,630	76,513	81,247	
Total	279,618	307,722	343,444	. .
Destructive uses				
Non-aluminum base alloys, powder and paste deoxidizers and other	10,811	13,724	12,835	
Total consumed	333,550	365,728	396,603	330,000
Secondary aluminum[1]	35,209	42,749	39,854	. .

	Metal Entering Plant		On Hand December 31	
	1974	1975	1974	1975
Primary aluminum ingot and alloys	379,525		97,585	
Secondary aluminum	33,114		3,510	
Scrap originating outside plant	54,083		10,381	
Total	466,722	. .	111,476	. .

Source: Statistics Canada.
[1]Aluminum metal used in the production of secondary aluminum.
[p]Preliminary; . . Not available.

has a 27 per cent interest in Halco and expects its shipments of bauxite from the Boke deposit to increase from the 1.46 million tons it received in 1975 to 2.6 million in 1979. Friguia, a bauxite and alumina producer, is a joint venture between the government of Guinea and several North American and European aluminum producers. Noranda Mines Limited has a 19.6 per cent interest in this producer. The third producer in Guinea is Office des Bauxites de Kindia, a state company operating with U.S.S.R. technical assistance. Three projects are being discussed to further develop the Guinea bauxite deposits; the largest is the Ayekoe project, where Guinean and Arab interests are planning to produce 9 million tons of bauxite and 2 million tons of alumina a year.

Plans have been completed for the development of the Oriximinia deposit on the Trombetas River in Brazil by Mineracao Rio do Norte S.A. Brazilian interests led by Companhia Vale do Rio Doce (CVRD), a state-owned company, hold 51 per cent of the project; Alcan holds 20 per cent and six other aluminum-producing partners share the remainder. The initial planned capacity is 2.6 million tons of bauxite a year, of which Alcan is to receive 1.2 million tons. Negotiations continued between CVRD and a consortium of five Japanese metal firms to construct a large continuous-process, refining-smelting complex near Belem, Brazil. The Japanese consortium has a 49 per cent interest in the Alumino do Brasil (Albras) project which was planned to have an annual capacity of 600,000 tons of aluminum a year. Cost of construction is estimated at more than $3 billion. The world recession has caused a delay in the start of this project and the initially-planned capacity may be reduced.

Indonesia has signed an agreement with a consortium of five Japanese aluminum producers and seven trading companies for the development of the Asahan power and aluminum-smelting complex on the island of Sumatra. The joint venture company, PT Indonesia Asahan Aluminum, will build a hydroelectric plant on the Asahan River and a smelter on the sea-coast. The smelter is expected to come on stream in 1981 at 75,000 metric tons a year and will be expanded to 225,000 metric tons a year. The cost of the project is estimated at over $830 million. The Indonesian state mining enterprise, P.T. Aneka Tambang, has been planning a 500,000-ton-a-year alumina refinery on Bintan Island but the project was postponed when Japan's three largest aluminum producers withdrew from the proposed $275 million venture.

Alcan Aluminum Limited and its two partners in Alcan Ireland Limited have decided to postpone the start of construction of their proposed alumina plant in the Republic of Ireland. The decision is expected to be reviewed in from 12 to 18 months. The project calls for construction of an alumina plant with an annual capacity of 880,000 tons at Aughinish on the Shannon River estuary.

In Japan, Sumitomo Chemical Co. Ltd. delayed the start up of the 55,000-ton first stage of its Toyo smelter from spring until fall and, in October, Mitsui Aluminum Company started up a new 43,500-ton-a-year potline at its Miike aluminum smelter that had been completed the previous December. Mitsui is also continuing construction on a second potline that is scheduled for completion in 1976. The Furukawa Aluminum Co. Ltd. began construction of its 70,000-ton-a-year smelter at Fukui, Japan. Completion is scheduled for late 1977 and plans call for eventually doubling its capacity. Sumikei Aluminum has started construction of a 50,000-ton-a-year smelter at Yamagata. The facility is scheduled for completion at the end of 1976 and the company is planning to double, and eventually quadruple, its capacity. Mitsubishi Chemical Industries Ltd. completed a 55,000-ton-a-year addition to its 110,000-ton smelter in Sakaide, Japan.

In the United States, Noranda Aluminum Inc. continued construction to double the capacity of its smelter at New Madrid, Missouri to 140,000 tons a year of alumninum in the second half of 1976. Six Japanese companies have withdrawn from the proposed 240,000-ton-a-year expansion of Revere Copper and Brass, Incorporated's alumnum smelter in Scottsboro, Alabama. Start up of the facility was originally scheduled for 1976. Revere's alumnia plant in Jamaica would also have been expanded by 600,000 tons a year to meet the additional alumina requirements. The partnership of Alumax Inc. and Howmet Corporation started the second 86,700-ton-a-year potline of their Eastalco smelter at Frederick, Maryland and it was approaching capacity operation at the end of the year. The Aluminum Company of America (Alcoa) placed in partial operation a new potline of 130,000-ton capacity at its Massena, New York smelter and continued construction of a 60,000-ton-a-year expansion of its Badin, North Carolina, smelter.

In other international developments, Bharat Aluminum Company started up the first of its four 27,500-ton-a-year potlines of its Korba, India, smelter. Kaiser Aluminum & Chemical Corporation is adding a fifth potline at its Tema, Ghana smelter run by the Volta Aluminum Company which will increase capacity by 50,000 tons to 220,000 tons in 1976. Plans by international consortia to construct alumina plants in the Philippines and the Solomon Island were deferred because of adverse conditions in the aluminum market.

Table 4. World primary aluminum production and consumption, 1974 and 1975

	Production		Consumption	
	1974	1975	1974	1975[e]
	(thousand short tons)			
United States	4,903	3,850	5,629	3,898
Europe[1]	3,635	3,532	3,701	3,065
Japan	1,233	1,117	1,417	1,352
Canada	1,125	978	397	330
Australia and New Zealand	363	357	233	185
Asia (excluding Japan and China)	380	421	392	397
Africa	308	303	133	120
America (excluding United States and Canada)	278	290	442	408
Sub-total	12,225	10,848	12,344	9,755
Communist countries[2]	3,117	3,122	2,849	2,921
Total	15,342	13,970	15,193	12,676

Sources: World Bureau of Metal Statistics; for Canada, Statistics Canada; for United States production, U.S. Bureau of Mines Commodity Data Summaries.
[1]Includes Yugoslavia; [2]Excludes Yugoslavia.
[e]Estimated.

Technology

Pechiney Ugine Kuhlmann Development, Inc. and Alcan Aluminum started construction on their jointly-owned pilot plant near Marseilles, France for the

Table 5. Canadian primary aluminum smelter capacity, 1975

Smelter location	Annual capacity
	(short tons)
Aluminum Company of Canada, Limited	
Quebec	
Arvida	447,000
Isle-Maligne	110,000
Shawinigan	92,000
Beauharnois	52,000
British Columbia	
Kitimat	299,000
Total Alcan capacity	1,000,000
Canadian Reynolds Metals Company, Limited	
Quebec	
Baie-Comeau	175,000
Total Canadian capacity	1,175,000

Source: Compiled from various company reports by the Mineral Development Sector, Department of Energy, Mines and Resources, Ottawa.

development of a process to produce alumina from non-bauxite raw materials such as clays and shale. The pilot plant is scheduled to produce 20 tons a day of high grade alumina using Pechiney's H-Plus process, commencing in 1976. The process is said to produce a purer alumina than that resulting from the traditional Bayer process, and thus reduce smelting costs. If the process proves feasible it could progressively free producers from dependence on bauxite. It is expected that sufficient data to accurately assess the process will be available by 1979. Estimated capital costs and operating expenses of the plant are about $25 million.

The Aluminum Company of America expects its new Alcoa smelting process to substantially cut energy consumption per pound of aluminum produced by about 30 per cent below the national average. In the process, alumina is combined with chlorine to form aluminum chloride which, in turn, is separated into molten aluminum and chlorine at relatively low temperatures. Alcoa will give the process its first commercial test when its 30,000-ton-a-year smelter at Palestine, Texas, comes on stream in 1976. The smelter may be expanded to 300,000 tons a year if the process proves commercial.

Earth Sciences Incorporated, National Steel Corporation and Southwire Aluminium Company have been pilot-plant testing for more than two years a process for extracting alumina from alunite. Called the Alumet Partnership, the project proposes to produce 500,000 tons of alumina a year plus 250,000 tons of potash and 500,000 tons of triple superphosphate from alunite deposits near Cedar City, Utah. Alumet is awaiting an environmental impact statement from the United States Bureau of Land Management which is expected to be completed in 1976. If the study is favourable, the plant could be in production in 1979.

Uses

Characteristics such as lightness, combined with strength, pleasing appearance, corrosion resistance, conductivity and heat reflectivity, provide many advantages favouring the use of aluminum. It may be cast, rolled, extruded and forged with ease compared with many of its competitive materials. In the United States, by far the world's largest market, the construction field continued to be the largest consumer in 1975, accounting for 23 per cent of shipments according to the Aluminum Association. Containers and packaging was in second place with 20 per cent, followed by transportation, 17 per cent; electrical uses, 12 per cent; consumer durables, 8 per cent; and machinery and equipment, 7 per cent. In many of the other main consuming countries transportation ranks first as a consumer.

The construction field in the United States was depressed in 1975 and aluminum consumption in this sector declined almost 27 per cent compared with 1974. The importance of housing construction to the aluminum industry is obvious when one considers that the average new conventional or mobile home in the United States contains about 1,000 pounds of aluminum. The increasing use of aluminum cans for beer and soft drinks continues to be a major growth factor, aided by public acceptance of the efforts of governments and industry to recycle the used cans.

New markets

There are two fields that have prospects of greatly increased use of aluminum. The first is the automotive where the average use of aluminum in passenger cars manufactured in North America rose from 76 pounds in 1973 to 84 pounds in 1975 and is expected to average about 87 pounds in the 1976 model year. The United States Senate has passed a fuel economy bill calling for a 50 per cent improvement in automotive fuel consumption by 1980 and the Aluminum Association expects the average new car to contain between 160 and 200 pounds of aluminum in that year. The second major field is cryogenic tanks for holding liquefied natural gas (LNG). There are extensive plans to ship this form of energy from overseas natural gas producers to areas experiencing an energy shortage, such as the United States, Europe and Japan. Aluminum is expected to be used in both the ships transporting LNG and for onshore storage vessels.

Prices

Published prices for aluminum remained firm during the year despite the slump in demand and the cutback

Table 6. Estimated world production of bauxite in 1975

	Production (millions of short tons)
Australia	22.4
Jamaica	14.0
Guinea	7.8
Surinam	6.5
France	3.3
Greece	3.0
Guyana	2.7
United States	2.0
Other noncommunist countries[1]	6.9
Total noncommunist countries	68.6
Communist countries	10.9
World Total	79.5

Source: United States Bureau of Mines Commodity Data Summaries, January 1976.
[1]Production of Yugoslavia included.

in operating rate by the producing companies. The United States published price for 99.5 per cent primary ingot was 39 cents a pound during the first half of the year. In late June, North American producers announced a 2 cent price increase but the United States Council on Wage and Price Stability requested a 30-day delay on the increase and it did not become effective until August. Free market prices remained below the North American price throughout the year.

Outlook

A slow economic recovery is foreseen in 1976 and the recovery in demand for aluminum from the lows of 1975 is expected to gather momentum during the year, with the United States market showing the best rate of recovery. Some increases in aluminum prices can be expected, to meet higher operating costs and to justify the reactivation of the higher-cost installations that were shut down early in the recession. Aluminum companies will start reviving plans for additions to capacity that had been postponed or cancelled during the recession.

The need to conserve energy will spur the growth of the recycling industry. Recycled aluminum consumes less than 15 per cent of the energy required to extract aluminum from virgin material.

It will probably be well into 1977 before demand has increased enough to justify the reactivation of all of the presently idle capacity. If, after 1977, aluminum consumption resumes its long-term growth rate of 6 to 8 per cent, some further additions to capacity above those on the drawing board will be required to meet the demand after 1980.

Tariffs

Canada

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
32910-1	Bauxite	free	free	free	free
35301-1	Aluminum pigs, ingots, blocks, notch bars, slabs, billets, blooms and wire bars	free	1¢ per lb	5¢ per lb	—
35302-1	Aluminum bars, rods, plates, sheets, strips, circles, squares, discs and rectangles	free	2¢ per lb	7.5¢ per lb	free
35303-1	Aluminum channels, beams, tees and other rolled, drawn or extruded sections and shapes	free	12½%	30%	free
35305-1	Aluminum pipes and tubes	free	12½%	30%	free
92820-1	Aluminum oxide and hydroxide; artificial corundum (this tariff includes alumina)	free	free	free	free

Tariffs (concl'd)

United States

Item No.		
417.12	Aluminum compounds: hydroxide and oxide (alumina)	free
601.06	Bauxite	free
618.01	Unwrought aluminum in coils, uniform cross section not greater than 0.375 inch	1.2¢ per lb
618.02	Other unwrought aluminum, excluding alloys	1¢ per lb
618.04	Aluminum silicon	1¢ per lb
618.06	Other aluminum alloys	1¢ per lb
618.10	Aluminum waste and scrap	0.7¢ per lb

Sources: For Canada, The Custom Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa. For United States, Tariff Schedules of the United States Annotated (1976) TC Publication 749.
Various tariffs are in effect on more advanced fabricated forms of aluminum.
— Nil.

Antimony

G.R. PEELING

Canada's production of antimony is derived as a byproduct of lead smelting operations, principally in the form of antimonial lead, but also as antimonial dross and, in much smaller quantities, as high-purity antimony metal. The value of the antimony content of primary antimonial lead produced in 1975 was $835,000 compared with $879,897 in 1974. The value of antimony contained in ores and concentrates produced in 1975 was $4,681,000 compared with $4,739,097 in 1974. The quantity of antimony contained in ores and concentrates is withheld to protect the confidentiality of the producer.

Antimony metal, antimony oxide and antimony salts are imported to meet Canadian needs. Regulus (metal) import statistics were discontinued in 1964. Imports of antimony oxide in 1975 totalled 871,000 pounds, of which Britain supplied 93 per cent, the United States 6.8 per cent and the People's Republic of China 0.2 per cent.

Cominco Ltd., which operates a lead smelter and refinery at Trail, British Columbia, is the main producer of primary antimonial lead in Canada. Its antimonial lead has a variable antimony content up to 23 per cent, depending on customers' requirements. Cominco Ltd., procuded 401 tons* of antimony in antimonial lead in 1975 compared with 244 tons in 1974. The low production in 1974 was a result of a four-month strike which shut down the Trail operations. The only other primary producer of antimonial lead is Brunswick Mining and Smelting Corporation Limited, Smelting Division, which operates a lead smelter at Belledune, New Brunswick. About 135,000 pounds of antimonial lead (10 per cent antimony content) was procuded at the plant in 1975. Secondary smelters recovered antimonial lead from scrap metal but no recent information is available concerning this production.

Domestic sources and occurrences

Most of the antimonial lead produced at Trail is a byproduct of the lead concentrate obtained from ores of Cominco's Sullivan mine at Kimberley, British Columbia. Other sources are the lead-silver ores and concentrates shipped to Trail from other Cominco mines and from custom shippers. The lead bullion produced from the smelting of these ores and concentrates contains about one per cent antimony, which is recovered in anode residues from the electrolytic refining of the lead bullion, and in furnace drosses produced during purification of the cathode lead. These residues and drosses are treated to yield antimonial-lead alloy, to which refined lead may be added to produce marketable products of the required grade. At Belledune, the Brunswick Mining and Smelting plant recovers antimonial lead alloys of whatever grade the market demands.

Consolidated Durham Mines & Resources Limited operates Canada's only antimony mine. It mines low-angle dipping veins containing stibnite, Sb_2S_3, at its Lake George property near Fredericton, New Brunswick. The mine has five levels, with the bottom level 545 feet below surface. The mill capacity of 400 tons a day, treated 70,992 tons of feed in 1975. Recovery was about 92 per cent. Concentrates, which average slightly over 65 per cent antimony, are shipped mainly to Europe, with small amounts going to the United States and Japan. At year-end 1975, reserves were 341,000 tons grading 5.93 per cent antimony. In mid-1975 the company undertook a $75,000 study to determine the economic feasibility of constructing an antimony smelter-refinery complex at the mine site. A crude oxide smelter is estimated to cost $1.5 million and an integrated smelter-refining complex is estimated to cost about $7 million. Discussions with the New Brunswick government and federal government regarding financing for this project are continuing.

Equity Mining Capital Limited is continuing exploration of its silver-gold-copper-antimony property near Houston, British Columbia. Reserves, mineable by open pit, are 43,511,000 tons grading 2.78 ozs. silver, 0.026 oz. gold, 0.33 per cent copper and 0.82 per cent antimony a ton. Initial bench scale studies indicate that the antimony can be extracted from the concentrates and that the antimony could become an important

*The short ton of 2,000 pounds is used throughout unless otherwise stated.

Table 1. Canada, antimony production, imports and consumption, 1974-75

	1974		1975[p]	
	(pounds)	($)	(pounds)	($)
Production				
Antimonial lead alloy	487,748	879,897	430,000	835,000
Antimony in ores and concentrates	. .	4,739,097	. .	4,681,000
Total	. .	5,618,994	. .	5,516,000
Imports				
Antimony oxide				
United Kingdom	1,284,100	1,543,000	808,900	1,282,000
United States	295,200	412,000	59,900	100,000
People's Republic of China	—	—	2,200	3,000
Bolivia	176,300	126,000	—	—
Total	1,755,600	2,081,000	871,000	1,385,000
Consumption				
Antimony regulus (metal) in production of				
Antimonial lead alloys	1,752,717	. .	. .	. .
Babbitt	100,123	. .	. .	. .
Solder	118,457	. .	. .	. .
Type metal	28,579	. .	. .	. .
Other commodities[1]	169,000	. .	. .	. .
Total	2,168,876	. .	. .	. .

Source: Statistics Canada.
[1]Includes foil, bronze, lead-base alloys, drop shot and other minor commodities.
[p]Preliminary; — Nil; . . Not available.

Table 2. Antimony, Canadian production, imports and consumption, 1966-75

	Production[1] all forms	Imports regulus	Consumption[2] regulus
		(pounds)	
1966	1,405,681	. .	1,098,162
1967	1,267,686	. .	1,190,179
1968	1,159,960	. .	1,169,631
1969	820,122	. .	1,305,742
1970	726,474	. .	1,142,009
1971	323,525	. .	1,481,522[r]
1972	. .	. .	2,026,300
1973	. .	. .	979,566
1974	. .	. .	2,168,876
1975[p]	. .	. .	. .

Source: Statistics Canada.
[1]Antimony content of antimonial lead alloy. [2]Consumption of antimony regulus (metal), as reported by consumers. Does not include antimony in antimonial lead produced by Cominco Ltd.
[p]Preliminary; . . Not available; [r]Revised.

byproduct of the operation. The feasibility study will not be completed until the first quarter of 1976. If a favourable decision is made, the property could be in production by the end of 1977 at an initial rate of 3,000 tons a day, with a later increase to 4,500 tons a day.

World review

World mine production of antimony in 1975, as estimated by the United States Bureau of Mines, with Canadian production added, totalled 84,550 tons, 5,366 tons less than in 1974.

Antimony is produced from ores and as a smelter byproduct in about 25 countries. The major sources of ore are the Republic of South Africa, the People's Republic of China, Bolivia, U.S.S.R., Mexico, Turkey and Yugoslavia. Prior to 1935, China, which reputedly has over 50 per cent of the world's reserves, produced two-thirds of the annual world output of antimony, but during the Chinese-Japanese War the centre of production shifted to the Americas. The United States, Mexico and Bolivia were the leading world suppliers of antimony during and immediately after World War II. In the years following the Korean War, South Africa, China and Bolivia became the major suppliers.

Republic of South Africa. Consolidated Murchison Limited operates the world's largest antimony mine near Gravelotte in northeast Transvaal. It has a mining and milling capacity of 660,000 tonnes a year of stibnite ore averaging 3 per cent antimony. In 1975, the company produced 25,160 tonnes of cobbed ore and concentrates, compared to 26,055 tonnes in 1974. Because of high arsenic content in some concentrates, Murchison sold only about 80 per cent of production in 1975. A leaching process is being studied to produce high purity antimony sulphide and the company expects to construct a pilot plant to be in operation in 1977. As part of an expansion program, two new shafts (the Athens and Beta) are being sunk to allow the current milling rate to be maintained. The mine should be able to operate at its present level of output for another eight years. In April 1974 the company began production of crude antimony oxide at its plant situated near the mine. The plant has an annual capacity of 7.2 million pounds of crude oxide, all of which is purchased by Chemetron Corporation, a United States' company based in Chicago.

Bolivia. A new antimony smelter was commissioned at Oruro in September 1975. Its annual capacity is 5,000 tons of 99.6 per cent antimony regulus and 1,000 tons antimony trioxide. A planned second-stage development will increase capacity to 11,000 tons a year regulus, but no date for expansion has been announced yet. The Bolivian government has also given approval for a feasibility study to be undertaken concerning the establishment of a second antimony smelter. The plant will likely be in the southern part of the country and will have the capability of producing 5,500 tons a year of antimony trioxide. Such a plant is not likely to come on stream before 1978-79.

Australia. New England Antimony Mines has contracted to sell its entire antimony concentrate output from the Hillgrove mine in New South Wales to Samincorp of New York. As a result of this agreement, the Hillgrove mine will be expanded by 30 to 50 per cent. This should result in an output of between 1,600 to 1,900 tons of antimony concentrate (grading about 60 per cent Sb).

The Blue Spec gold-antimony mine in Western Australia which is being developed in a joint venture by Australian Anglo American Ltd., and Metramar Minerals Ltd., is scheduled to come into production late in the first quarter of 1976. Reserves are given as 80,000 tons grading 4.63 per cent antimony and 45.14 grams of gold a ton.

The Dorrigo mine which has been on a care and maintenance basis since early 1975 was offered for sale by public tender in September 1975 by Australian Antimony Corporation NL.

United States. N L Industries, Inc. operates the world's largest antimony smelter for ores and concentrates at Laredo, Texas, producing antimony metal and oxide, mainly from imported Mexican, South African and Bolivian ores and concentrates. The United States' mine production of antimony in 1975 was estimated to be 950 tons, 316 tons more than in 1974 and the highest level since 1971.

Primary smelter production was down 13 per cent from 1974 to 14,500 tons. The decrease was caused by a shortage of available feed from South Africa, which began antimony trioxide production in 1974. Imports were down 13 per cent for ores and concentrates and 45 per cent for metal. Oxide imports increased because Consolidated Murchison oxide production in South Africa is contracted to go to the Chemetron Corporation in Chicago. Consumption of all types of antimony dropped 12 per cent in 1975 to 36,000 tons.

Table 3. Canadian consumption of antimonial lead alloy[1], 1973-75

	1973	1974	1975
		(pounds)	
Batteries	1,912,526	2,363,462	. .
Type metal	201,182	246,000	. .
Babbitt	1,913	17,856	. .
Solder	6,518	6,142	. .
Other uses	1,000	5,044	. .
Total	2,123,139	2,638,504	. .

Source: Statistics Canada.
[1]Antimony content of primary and secondary antimonial lead alloy.
. . Not available.

Table 4. Canadian consumption of antimonial lead alloy[1], 1966-75

	(pounds)		(pounds)
1966	2,593,733	1971	2,175,085
1967	2,496,032	1972	2,168,825
1968	2,124,903	1973	2,123,139
1969	2,321,770	1974	2,638,504
1970	1,400,402	1975	. .

Source: Statistics Canada.
[1]Antimony content of primary and secondary antimonial lead alloys.
. . Not available.

The U.S. Antimony Corporation has entered into a joint venture with the Bolivian firm Impressa Minera Bernal Hermanos S.A. to construct an antimony trioxide plant in Montana. The plant will have a capacity of up to 3,500 tons a year antimony trioxide. Asarco Incorporated announced plans for construction of a $7 million antimony metal producing plant to be located in El Paso, Texas. The production will be based on copper-silver-antimony concentrates from mines in the Coeur d'Alene district of Idaho. The plant is scheduled to start production in late-1976 and will have a capacity of 1,825 tons a year of metal.

The recession which gripped all the major economies during late-1974, continued through most of 1975 and had a profound effect on antimony as demand weakened, consumption and production declined, and stocks increased. In the United States, stocks of metal increased from 10,500 to 14,500 tons. The major end-use markets suffered a disastrous year. The battery manufacturers produced 39 million units in 1975 compared to about 50 million in 1974. The paints and plastics sectors were depressed because of the slow-down in the construction and automobile industries.

The United States was again the noncommunist world's largest consumer of antimony and continued to depend on foreign suppliers (particularly South Africa, Bolivia, Chile and Mexico) for much of its requirements. Its consumer requirements in 1974 were about 20 per cent of the world primary supply.

There were no sales by the General Services Administration (GSA) of the United States from the government stockpile in 1975.

Table 5. World mine production of antimony, 1973-75

	1973	1974	1975[e]
	(short tons)		
Republic of South Africa	17,453	18,178	17,800
Bolivia	16,225	14,394	14,500
People's Republic of China	15,432	16,535	. . .
U.S.S.R.	8,267	8,267	. . .
Thailand	3,764	6,371	. . .
Turkey	2,976	6,473	. . .
Mexico	2,632	2,653	3,500
Yugoslavia	1,841	1,918	3,000
Australia	1,638	1,505	. . .
Italy	1,497	1,297	. . .
Morocco	1,213	2,039	. . .
Guatemala	1,060	882	. . .
Peru	899	937	. . .
United States	545	661	950
Canada	. .	3,600	4,000
Other countries	3,411	4,206	40,800
Total	78,853	89,916	84,550

Sources: For Canada, Statistics Canada. For other countries, World Metal Statistics, March 1976 for 1973 and 1974 and U.S. Bureau of Mines, Commodity Data Summaries, January 1976 for 1975.
[e] Estimated; . . Not available.
. . . Included in "Other countries".

Uses

Antimony is used principally as an ingredient in many alloys and in the form of oxides and sulphides.

Antimony hardens and strengthens lead and inhibits chemical corrosion. The use of antimonial lead in storage batteries remains its major outlet, but due to technological developments the antimony content in batteries has been progressively reduced in recent years, from about 12 per cent to current levels which vary from 3 to 6 per cent of the antimonial lead contained. Antimonial lead alloys are also used for power transmission and communications equipment, printing metal, solder, ammunition, chemical pumps and pipes, tank linings, roofing sheets and antifriction bearings.

Antimony oxide, Sb_2O_3, usually produced directly from high-grade sulphide ore, is used extensively in plastics and in flameproofing compounds.

Antimony trioxide or trichloride in an organic solvent has long been recognized as having significant flame-retardant properties and is now used extensively in carpets, rugs and carpet underlay. The trioxide is also a glass former, and is sought for its ability to impart hardness and acid resistance to enamel coverings for bathtubs, sinks, toilet bowls and refrigerators. The pentasulphide, Sb_2S_5, is used as a vulcanizing agent by the rubber industry. Burning antimony sulphide creates a dense white smoke that is used in visual control, in sea markers and in visual signaling.

Antimony is valuable for paint formulation since its high hiding power and various chemical compounds produce a wide range of pigments. High-purity metal is used by manufacturers of indium-antimony and aluminum-antimony intermetallic alloys as a semiconductor in transitors and rectifiers.

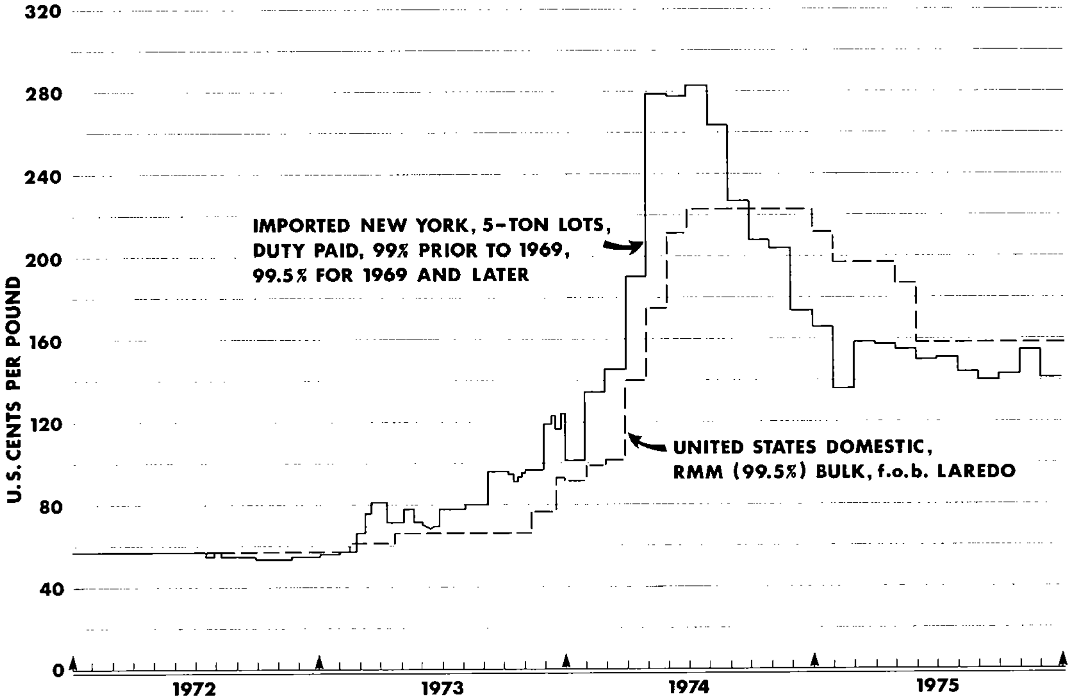
Outlook

The world outlook for antimony appears to be favourable. Although some of its traditional uses are in a no-growth or declining-use situation, the outlook is good for continued growth in oxide consumption for flame retardants and for increased production of antimonial lead alloys for battery manufacture. The latter category is suffering from inroads by calcium-lead, maintenance-free batteries, but nonetheless, traditional antimonial lead batteries will still be in a growth position through to 1980. The continued growth in these two largest sectors of usage will offset any decline in other applications such as type metal, piping, solder, etc.

The outlook for price in 1976 is also favourable. The price for metal and ores appears to have bottomed out in mid-1975, and 1976 should be a year of recovery as the western world economies pick up. Although there is not likely to be a price increase of the magnitude of 1973-74, there is evidence that a moderate increase is likely to take place in 1976. The damping effect of high inventories in 1975, a projected slow recovery in the major western world economies and the increasing reliability of ore supplies from China are the major reasons for predicting a moderate increase in the price of antimony in 1976.

ANTIMONY METAL PRICES

MINERAL DEVELOPMENT SECTOR
DEPARTMENT OF ENERGY, MINES AND RESOURCES



Source: METALS WEEK

Table 6. Industrial consumption of primary antimony in the United States, by class of material produced

Product	1973	1974	1975[p]
	(short tons, antimony content)		
Metal products			
Ammunition	122	121	239
Antimonial lead	8,027	7,251	4,023
Bearing metal and bearings	527	476	318
Cable covering	12	16	29
Castings	65	31	1
Collapsible tubes and foil	12	18	10
Sheet and pipe	97	69	59
Solder	191	205	75
Type metal	134	107	47
Other	104	135	36
Total	9,291	8,429	4,837
Nonmetal products			
Ammunition primers	18	11	10
Fireworks	5	11	6
Flameproofing chemicals and compounds	2,906	4,383	2,209
Ceramics and glass	1,917	1,384	933
Matches	—	—	—
Pigments	644	460	203
Plastics	2,920	1,431	479
Rubber products	693	664	222
Other	2,219	1,268	544
Total	11,322	9,612	4,606
Grand Total	20,613	18,041	9,443

Source: U.S. Bureau of Mines, *Minerals Yearbook* Preprint 1973, and Mineral Industry Surveys.
[p]Preliminary; — Nil.

Prices

Antimony metal prices, after a year and a half of strength began to slide in the second half of 1974 and this slide continued throughout 1975, with only the European free market price showing any positive activity late in the year. The European free market metal price (99.6% Sb, 1 ton lots, cif Europe) opened the year at £1,150-£1,350 a metric ton. The low for the year was recorded on January 14 at £1,075. After remaining in the doldrums for most of the year, the price moved steadily upward to the high for the year of £1,662.5 on November 11. The price subsequently settled into a range of £1,525-£1,575 for the remainder of the year.

The United States domestic price of antimony (RMM brand) as quoted in Metals Week, in bulk, 99.5 per cent Sb, fob Laredo, Texas, was $2.23 a pound at the beginning of the year. It decreased steadily during the first half and in June was quoted at $1.58 a pound. This price held to the end of December. The domestic price of Lone Star brand (99.8 per cent Sb) opened the year at $2.65, was quoted at $1.90 a pound in June and remained unchanged during the rest of the year.

Antimony lump-ore prices, 60 per cent antimony content, as quoted in *Metals Week,* reflected the general market trends. The quoted range at the beginning of the year was $26.50 to $27.50 (U.S) a short ton unit (stu). This was also the price high for the year. The price declined steadily to a range of $17.00 to $18.50 a stu in August and remained there till year-end.

Prices

United States prices in U.S. currency quoted in Metals Week.

	Jan. 2, 1975	June 12, 1975	Dec. 26, 1975
		($)	
Antimony ore lump content 60%, STU	31.00-32.00	19.00-20.00	17.00-18.50
		(¢)	
Antimony metal, RMM (99.5%)			
¢ per lb			
fob Laredo	223.00	158.00	158.00
fob N.Y.	225.00	160.00	160.00
Lone Star (99.8%)			
¢ per lb			
fob Laredo	265.00	190.00	190.00
fob N.Y.	267.00	192.00	192.00

Tariffs

Canada

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
33000-1	Antimony, or regulus of, not ground, pulverized or otherwise manufactured	free	free	free	free
33502-1	Antimony oxides	free	12½%	25%	free

United States

Item No.		
601.03	Antimony ore	free
632.02	Antimony metal unwrought on and after Jan. 1, 1972	1¢ per lb.

Sources: For Canada, the Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa. For United States, Tariff Schedules of the United States, Annotated (1976) T.C. Publication 749.

Asbestos

G.O. VAGT

Asbestos fibre output decreased nearly 40 per cent in 1975, mainly as a result of severe disruptions of production in Quebec. The most serious of these were a seven-month strike from March 18 to October 12 that stopped most mining and milling activity and a late 1974 fire that destroyed the King Beaver mill of Asbestos Corporation Limited. Also, a slide along one wall of the Jeffrey open-pit mine owned by Canadian Johns-Manville Company, Limited disrupted production from January to October and marginally reduced output for the year.

Canadian production (shipments)

Canadian production of asbestos fibre in 1975 was 1,143,000 tons* valued at $266,943,000, compared with 1,811,938 tons valued at $302,013,081 in 1974. Under normal conditions approximately 85 per cent of total production is from Quebec, 5 per cent each from British Columbia and Yukon Territory, 4.5 per cent from Newfoundland and less than 1 per cent from Ontario.

Canada exported 1.182 million tons of fibre. Under normal trade patterns, exports account for about 95 per cent of total production. This quantity provides the noted percentage of total asbestos imports: United States, 96 per cent; European Economic Community, 57 per cent; Japan, 39 per cent; Eastern Europe, 7 per cent and other, 54 per cent.

The value of Canadian exports of manufactured asbestos products in 1975 was $15,877,000 compared with $13,272,000 in 1974, according to Statistics Canada. The value of imports of manufactured asbestos products increased to $23,814,000 from $23,053,000 in 1974.

Canadian developments

The major developments of the asbestos-producing mines in Canada are listed in Table 2.

Production on a tune-up basis began in September at the Midlothian Township mine of United Asbestos Inc. The mine, located near Matachewan, Ontario, is this province's first large-scale asbestos producer. The mill is designed to handle 4,000 tons of ore a day, amounting to an annual output of 100,000 tons of mainly group 6 fibre. Measured ore reserves for purposes of planned open-pit mining amount to over 26 million tons averaging 7.7 per cent fibre content. Capital costs to production were approximately $26 million. The development and construction stage required three years, following the decision to proceed in 1972 when costs to production were estimated at only $18 million.

Asbestos Corporation Limited (ACL), and Bell Asbestos Mines, Ltd. concluded an agreement in late 1974 for an exchange of ore along their common boundary. This will facilitate complete extraction of the common orebody.

At Putuniq (Asbestos Hill), Ungava production was not affected by the strike in the Eastern Townships and the combined operations of ACL's Asbestos Hill mine and the mill at Nordenham in West Germany operated at full capacity for the first full year since operations began in 1972. An underground exploration program commenced at Putuniq to provide information for possible future development of underground mining methods.

Underground mining continued at the King Beaver mine, owned by Asbestos Corporation Limited, following the fire that destroyed the K.B. mill in 1974. Ore from this mine was transported for treatment at the two British Canadian mills situated in Black Lake. Feasibility studies and more detailed drilling to define ore reserves were carried out at the K.B. property to assess long-term plans regarding expansion of mill capacity.

Cassiar Asbestos Corporation Limited commissioned a new concentrator at the Cassiar, British Columbia, mine. Also, a new supplemental air system was installed in late 1974 and upgrading of environmental control equipment continued in 1975. Operations were stopped for a three-week period in March to improve environmental conditions in the concentrator and mill. Respirators are required in areas where fibre

* The short ton of 2000 pounds is used throughout unless otherwise stated.

Table 1. Canada, asbestos production and trade, 1974-75

	1974		1975[p]	
	(short tons)	($)	(short tons)	($)
Production (shipments)				
By type				
Crude, groups 1, 2 and other milled	21	23,663	. .	. .
Group 3, spinning	39,058	19,345,628	. .	. .
Group 4, shingle	518,625	131,455,729	. .	. .
Group 5, paper	279,971	60,129,781	. .	. .
Group 6, stucco	312,923	42,951,423	. .	. .
Group 7, refuse	660,947	48,093,467	. .	. .
Group 8, sand	393	13,390	. .	. .
Total	1,811,938	302,013,081[1]	1,143,000	266,943,000[1]
By province				
Quebec	1,536,710	234,415,857	854,000	176,634,000
British Columbia	91,936	27,398,900	97,000	38,809,000
Yukon	90,896	22,752,400	112,000	31,970,000
Newfoundland	75,941	16,111,107	64,000	18,135,000
Ontario	16,455	1,334,817	16,000	1,395,000
Total	1,811,938	302,013,081	1,143,000	266,943,000
Exports				
Crude				
Japan	17	18,000	45	22,000
United Kingdom	—	—	54	18,000
United States	159	48,000	103	5,000
France	6	7,000	—	—
Italy	6	3,000	—	—
Total	188	76,000	202	45,000
Milled fibre (groups 3, 4 and 5)				
United States	217,877	64,678,000	157,738	58,695,000
West Germany	108,768	27,369,000	112,632	38,193,000
United Kingdom	61,547	19,729,000	42,536	19,514,000
Mexico	28,893	9,593,000	27,945	12,122,000
Australia	37,867	9,180,000	29,538	10,970,000
Belgium and Luxembourg	30,402	9,005,000	23,593	9,091,000
France	46,777	13,340,000	23,893	8,809,000
Spain	35,937	10,847,000	19,158	7,277,000
Japan	53,090	13,346,000	22,568	6,660,000
Italy	24,438	7,189,000	15,206	6,229,000
India	14,734	4,176,000	12,528	5,263,000
Netherlands	14,190	3,811,000	12,110	4,427,000
Other countries	208,659	57,494,000	121,730	43,805,000
Total	883,179	249,757,000	621,175	231,055,000

Table 1 (cont'd)

	1974		1975p	
	(short tons)	($)	(short tons)	($)
Shorts (groups 6, 7, 8 and 9)				
United States	517,273	49,083,000	347,404	39,979,000
Japan	95,082	10,956,000	47,424	7,051,000
United Kingdom	52,168	4,928,000	31,424	3,642,000
West Germany	33,593	3,150,000	21,250	2,833,000
Netherlands	36,222	3,230,000	21,888	2,447,000
Belgium and Luxembourg	17,188	1,723,000	12,636	2,034,000
France	24,995	2,119,000	12,869	1,519,000
Argentina	6,842	731,000	6,890	867,000
Spain	13,090	1,713,000	5,149	848,000
South Korea	10,250	1,533,000	4,212	783,000
Mexico	5,085	645,000	4,292	684,000
Thailand	4,985	711,000	3,027	515,000
Venezuela	2,801	262,000	3,632	510,000
Australia	12,880	1,385,000	3,575	499,000
Brazil	14,261	906,000	3,922	416,000
Other countries	59,350	6,406,000	31,138	4,998,000
Total	906,065	89,481,000	560,732	69,625,000
Grand total crude, milled fibres and shorts	1,789,432	339,314,000	1,182,109	300,725,000
Manufactured products				
Asbestos cloth, dryer felts, sheets				
United States		1,914,000		1,164,000
Brazil		100,000		576,000
New Zealand		79,000		212,000
United Kingdom		133,000		163,000
Australia		160,000		109,000
Dahomey		—		88,000
Other countries		859,000		127,000
Total		3,245,000		2,439,000
Brake linings and clutch facings				
United States		864,000		1,056,000
Ecuador		65,000		270,000
France		49,000		165,000
Cuba		—		46,000
Australia		34,000		38,000
Lebanon		11,000		34,000
Hong Kong		10,000		33,000
Guatemala		80,000		30,000
Thailand		14,000		28,000
Other Countries		194,000		208,000
Total		1,321,000		1,908,000

Table 1 (concl'd)

	1974		1975p	
	(short tons)	($)	(short tons)	($)
Asbestos and asbestos cement building materials				
United States		3,704,000		4,226,000
Brazil		3,000		682,000
United Kingdom		137,000		589,000
Saudi Arabia		153,000		425,000
Iran		15,000		308,000
Australia		581,000		285,000
Dahomey		—		266,000
Iraq		336,000		264,000
Japan		59,000		81,000
Other countries		234,000		279,000
Total		5,222,000		7,405,000
Asbestos basic products, nes				
United States		3,213,000		3,791,000
France		33,000		97,000
Switzerland		21,000		71,000
Belgium and Luxembourg		7,000		44,000
Nigeria		—		17,000
Brazil		36,000		15,000
Mexico		1,000		13,000
Other countries		173,000		77,000
Total		3,484,000		4,125,000
Total exports, asbestos manufactured		13,272,000		15,877,000
Imports				
Asbestos, unmanufactured	4,334	1,266,000	5,667	2,290,000
Asbestos, manufactured				
Cloth, dryer felts, sheets, woven or felted		2,976,000		3,824,000
Packing		1,892,000		1,837,000
Brake linings		5,296,000		5,947,000
Clutch facings		1,350,000		734,000
Asbestos cement shingles and siding		112,000		179,000
Board and sheets		702,000		841,000
Asbestos and asbestos cement building materials, nes		8,203,000		7,696,000
Asbestos and asbestos cement basic products, nes		2,522,000		2,756,000
Total asbestos, manufactured		23,053,000		23,814,000
Total asbestos, unmanufactured and manufactured		24,319,000		26,104,000

Source: Statistics Canada.
[1] Value of containers not included.
p Preliminary; — Nil; nes not elsewhere specified; . . Not available.

counts exceed the new provincial in-plant standard of 5 fibres per cubic centimeter. At Cassiar's Clinton Creek mine, Yukon Territory, a new air system was installed in late 1974. Work continued in a few areas where it was required in order to better control dust emissions. Recent diamond drilling failed to up-grade reserves that were previously classified to the possible category, and as a result the mine is expected to close in 1978.

At the Advocate Mines Limited property in Baie Verte, Newfoundland, a new mining plan was designed to accelerate waste removal. Benefits are expected to be fully realized in 1978, and a slight increase in fibre output is planned at that time.

The Reeves mine near Timmins, Ontario, owned by Canadian Johns-Manville Company, Limited, (CJM) closed in February 1975 as a result of difficulties in complying with the new provincial asbestos fibre emission standard of 2 fibres per cubic centimetre of air. CJM produced asbestos from its Bolduc deposit located near Barraute, Quebec. Output is approximately 20,000 tons of fibre a year following primary milling on site and final milling at Asbestos, Quebec. The operation is expected to have only a three-year life.

Prospective producers

Abitibi Asbestos Mining Company Limited, now 59 per cent owned by Brinco Limited, is potentially a large producer from a property 52 miles north of Amos, Quebec. Feasibility studies by Brinco are advanced and ore reserves in the "A" deposit are estimated at 100 million tons averaging 3.5 per cent asbestos fibre. The most recent cost estimate is $292 million to bring the Abitibi project into production at a rate of 220,000 tons of fibre a year.

Rio Algom Limited continued evaluation of the Roberge Lake asbestos deposit situated in McCorkill Township, about 20 miles east of Chibougamau, Quebec. This deposit is owned by McAdam Mining Corporation Limited. Rio Algom will earn a 70 per cent interest if production results.

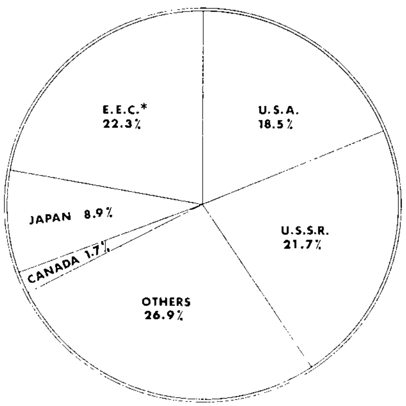
Algoma-Talisman Minerals Limited recently formed a joint venture with the Shield Development Company Limited to undertake exploration of an asbestos-bearing property discovered in the Rush Lake — Horwood Lake area in Newton Township, about 65 miles southwest of Timmins, Ontario.

Hollinger Mines Limited plans to evaluate an asbestos prospect on its Rundle Gold Mines Limited property, also in Newton Township, Ontario.

World production and developments in major markets

Total world production of asbestos fibre in 1975 was an estimated 5,531,989 tons based on the inclusion of all grades between one and seven recovered in the U.S.S.R. Chrysotile accounted for about 91 per cent of world production and the remaining production was made up of about 6 per cent crocidolite (blue asbestos) and 3 per cent amosite. Less than one per cent of other

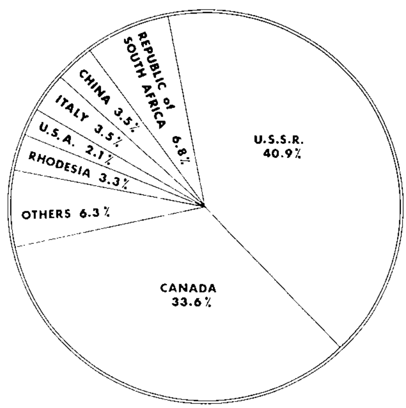
ASBESTOS
APPARENT WORLD CONSUMPTION
1974



APPARENT CONSUMPTION 4,016,524 m.t.

Source: EMR estimates from numerous sources.
*9 countries

ASBESTOS
WORLD PRODUCTION
1974



PRODUCTION 4,891,875 m.t.

Source: EMR estimates from numerous sources.
Includes grades 1-7 from U.S.S.R.

Table 2. Canadian asbestos producers and prospective producers, 1975

	Mine Location	Mill Capacity	Remarks
		(metric tons (tonnes) of ore/day)	
Producers			
1. Advocate Mines Limited	Baie Verte, Nfld.	6,800	Open pit. Produces fibre equivalent groups 4 and 6.
2. Carey-Canadian Mines Ltd.	East Broughton, Que.	5,000	Open pit. Mainly produces group 7 fibre.
3. Asbestos Corporation Limited			World's major independent asbestos producer.
Asbestos Hill mine	Putuniq, Que.	5,400	Annual rated capacity 272,000 tonnes of concentrate. Final processing to 91,000 tonnes of fibre done at Nordenham, W. Germany.
British Canadian mine	Black Lake, Que.	11,200	Open pit, two milling plants. Also processes ore from K.B. mine.
King Beaver mine	Thetford Mines, Que.		Underground and open pit. Mill closed by fire in December 1974.
Normandie mine	Black Lake, Que.	6,800	Open pit.
4. Bell Asbestos Mines, Ltd.	Thetford Mines, Que.	2,700	Underground.
5. Lake Asbestos of Quebec, Ltd.	Black Lake, Que.	8,200	Open pit.
National Mines Division	Thetford Mines, Que.	3,200	Open pit.
6. Canadian Johns-Manville Company, Limited			
Jeffrey mine	Asbestos, Que.	30,000	Open pit is western world's largest known asbestos deposit. Expanded complex designed to maintain annual output at a minimum of 544,000 metric tons of fibre.
Reeves mine	Timmins, Ont.	4,500	Open pit. Closed in February as result of stricter environmental regulations.
7. Hedman Mines Limited	Matachewan, Ont.	300	Open pit.
8. United Asbestos Inc.	Matachewan, Ont.	3,600	Commenced production in September.
9. Cassiar Asbestos Corporation Limited			
Cassiar mine	Cassiar, B.C.	3,000	Open pit.
Clinton mine	Clinton Creek, Yukon	3,600	Open pit. Closure expected in 1978.
Prospective Producers			
10. Abitibi Asbestos Mining Company Limited	Amos, Quebec	11,800	Feasibility study underway.
11. McAdam Mining Corporation Limited	Chibougamau, Quebec	4,500	Feasibility study underway.
12. Cassiar Asbestos Corporation Limited	Dease Lake, B.C.		Possible future development.

Source: Mineral Development Sector, Department of Energy, Mines and Resources, Ottawa.

types of asbestos, including tremolite and anthophyllite, were produced, mainly in the United States. Discrepancies occur in the available data from the U.S.S.R. and also in the interpretation of this data, resulting in problems of statistical correlation. Canada's production of only 1,143,000 tons was entirely chrysotile and in 1975 was far lower than the level of production in the U.S.S.R., which was an estimated 2.68 million tons. The included diagrams show a breakdown of 1974 world production as well as world consumption.

Asbestos reserves in the U.S.S.R. are known to be very large and are probably greater than those in Canada. The three major producing areas in the U.S.S.R. are: the Bazhenov deposits of the Central Urals near Sverdlovsk, about 900 miles east of Moscow, where there is capacity of about 1.5 million tons per year (tpy) of fibre; the Dzhetygara District, Northwest Kazakhstan, along the eastern flanks of the southern Urals, where a capacity of about 500,000 tpy is reported; Aktovrak, Tuva district, to the west of Lake Baikal, where expansions are expected to result in a productive capacity approaching 500,000 tpy.

The Republic of South Africa has the only commercial deposit of amosite and is also a major producer of crocidolite as well as chrysotile. Approximately 25 per cent of that country's total asbestos production of nearly 400,000 tons is accounted for by chrysotile. Production was affected by political tensions in the country and labour shortages in the mines. Also, shipments from southern Africa and Swaziland through the port of Laurenço Marques were disrupted by political upheavals in Mozambique. Asbestos Investments (Pty) Ltd., owned by the Eternit Group, opened a new crocidolite mine at Klipfontein in Cape province.

Cassiar Asbestos dropped its option on the Pyke asbestos project in New Zealand.

In the United States, General Aniline and Film Corporation sold its interests in the Lowell mine, Vermont, to an employee group that will continue to operate the mine and mill. The Johns-Manville Corporation mine at Coalinga, California and the Copperopolis mine, owned by Pacific Asbestos Corporation, Limited in Calaveras County, California remained closed in 1975.

Woodsreef Mines Limited, N.S.W., Australia, operated at a higher level of output, although the company is in the hands of receivers. An engineering study concluded that the project could be more viable if the capacity of the plant were increased.

The Zidani (Kozani) mine in northern Greece, 51 per cent owned by Cerro Corporation and 49 per cent by the Hellenic Industrial Development Bank, continued to be evaluated by pilot plant tests. Initial annual production of asbestos is expected to be approximately 50,000 tons.

In Finland, Paraisten Kalkki Oy closed its anthophyllite mine in January but continued to mill fibre until July. Marketing problems and labour shortages were two of the reasons given for closure.

A company in Turkey has plans to establish a new mine which would produce 10,000 tons of chrysotile a year near Mihalliccik.

Other asbestos developments in the world are in Colombia, Brazil and Mexico. A property owned 70 per cent by Eternit Colombianos is being developed in Colombia by Asbestos Colombianos S.A. Plans are for production of 15,000 tons of chrysotile a year. In Brazil the chrysotile asbestos mine at Cana Brava, which presently produces over 70,000 tons of fibre a year, is projected to produce 115,000 tons a year by 1979. In Mexico, Compania Minera Pegaso S.A. continued development of the Oaxaca chrysotile deposit. There was no reported progress from the Cuidad Victoria deposit.

Canada exports over 95 per cent of its total production of asbestos fibre to more than 70 countries. Normally this amounts to over 1.7 million tons a year (1974), with nearly 80 per cent of the exports distributed among the following 10 countries: United States (41.5), Japan (8.2), West Germany (7.9), United Kingdom (6.3), France (4.0), Australia (2.9), Spain (2.7), Belgium and Luxembourg (2.6), Mexico

Table 3. Canada, asbestos production and exports, 1966-75

	Crude	Milled	Shorts	Total
	(short tons)			
Production[1]				
1966	215	735,972	752,868	1,489,055
1967	288	705,295	746,521	1,452,104
1968	290	777,006	818,655	1,595,951
1969	7,017	687,924	916,227	1,611,168
1970	7,252	737,037	917,355	1,661,644
1971	2,029	753,241	879,309	1,634,579
1972	101	807,327	879,623	1,687,051
1973	45	837,590	1,025,341	1,862,976
1974	21	837,654	974,263	1,811,938
1975[p]	. .	. .	. .	1,143,000
Exports				
1966	172	732,585	713,405	1,446,162
1967	229	653,280	688,535	1,342,044
1968	202	723,136	736,330	1,459,668
1969	135	778,641	785,986	1,564,762
1970	101	824,324	738,007	1,562,432
1971	115	780,137	795,485	1,575,737
1972	112	784,828	848,157	1,633,097
1973	35	926,670	944,926	1,871,631
1974	188	883,179	906,065	1,789,432
1975[p]	202	621,175	560,732	1,182,109

Source: Statistics Canada.
[1] Producers' shipments.
[p] Preliminary; . . Not available.

(1.9) and Italy (1.3) per cent. Most of the annual output from the U.S.S.R. is consumed internally, although about 600,000 tons are exported, mainly to eastern European countries, Japan, France, West Germany and India.

Fibre groups, uses and technology

To evaluate the quality of asbestos fibre there are five basic properties which must be considered: fibre length distribution, fibre bundle diameter distribution, harshness, tensile strength and surface activity. Other properties governing quality are iron content, colour and dust content. The major standard on a length basis is that developed by the industry in Quebec, whereby asbestos is classified and priced by groups from the largest fibre specified as No. 1, to the shortest, No. 9. Because there are more than 3,000 uses for asbestos, it is more appropriate to classify the groups in categories and describe the major purposes the fibres serve than to list the products in which they are used.

Long fibres, Crudes No. 1 and 2 and Group 3. — used in the textile industry, as electrical insulation, as a filtration medium and as reinforcing fillers in asbestos-cement products where great strength is required.

Medium-length fibres, Groups 4,5,6. — reinforcing fillers in asbestos-cement products, friction materials such as brake linings and clutch facings, paper and pipe coverings.

Short fibres, Groups 7,8,9. — reinforcing fillers in plastics, floor tile, asphalt, and in paints and oil-well muds.

A breakdown of United States asbestos demand based on United States Bureau of Mines statistics for 1974 was as follows: asbestos cement construction products, 37.4 per cent; flooring products, 18.1 per cent; friction products, 9.5 per cent; roofing products, 9 per cent; paper products, 7.4 per cent; packing and gaskets, 3.4 per cent; textiles, 2.4 per cent; insulation, 1.7 per cent and others, 11.1 per cent.

A national asbestos emission standard that will specify the maximum dust that may enter the atmosphere surrounding mining operations and milling plants is being developed by Environment Canada. Initially, standards will apply to crushing, drying, milling and storage. In-plant emission standards are a provincial concern and these are being enforced in Ontario (2 fibres/cc) and in British Columbia (5 fibres/cc). Regulations are expected to become effective in Quebec and the Yukon Territory in 1978.

In June the Quebec government created a study committee concerned with health and environmental factors in the asbestos industry. This committee, headed by Judge R. Beaudry, has the same powers and privileges as a Commission of Inquiry and has the mandate to advise the government on various subjects relating to the final establishment of environmental control regulations. In the Yukon Territory, a Territorial Task Force was established and has recommended that the present standard for airborne asbestos be reduced from the present 5 fibres per cubic centimetre to 2 fibres per cubic centimetre by July, 1978.

Proposed regulations on asbestos transportation and use in Canada will be released under the Hazardous Products Act by the federal Departments of Health and Welfare and Consumer and Corporate Affairs. Industry has been alerted to the fact that the impending regulations would ban the importation of crocidolite. Certain consumer products containing free asbestos fibres were banned from sale in 1975. The sale of nonconsumer products containing asbestos would also be regulated by identifying shipments with labels to help assure safe handling and usage. The labelling would alert workers, unions, management and the public to the hazardous nature of the contents of the shipment.

Outlook

The strong-demand and tight-supply situation, along with rising prices in the last two years, stimulated expansion and development at properties in Canada and throughout the world. Proposed developments in many parts of the world, however, have not kept pace with normal growth in consumption, and Canada continues to be in a favorable position to supply a large proportion of projected increases in world demand.

Canadian asbestos price[1] quoted in Asbestos[2]

	Dec. 1, 1975
	($ per short ton)
Quebec, fob mines	
Crude No. 1	3,496
Crude No. 2	1,899
Group	
No. 3 (spinning fibre)	891-1,463
No. 4 (asbestos-cement fibre)	492- 829
No. 5 (paper fibre)	278- 392
No. 6 (waste, stucco, plaster)	236- 244
No. 7 (refuse, shorts)	89- 198
	Jan. 1, 1976
Cassiar, fob North Vancouver, B.C.	
Canadian group	
No. 3 (nonferrous spinning fibre)	
AAA grade	1,820
AA grade	1,447
A grade	1,102
No. 4 AC grade (asbestos cement) (single fibre)	794
No. 4 AK grade	566
No. 4 CP grade	531
No. 4 AS grade	490
No. 4 CT grade	481
No. 5 AX grade	449
No. 5 CY grade	315
No. 5 AY grade	315

[1]As of December 1, 1975 and January 1, 1976. [2]*Asbestos* is a magazine published monthly by Stover Publishing Company.

Tariffs

Canada

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
		(%)	(%)	(%)	(%)
31210-1	Asbestos, crude	free	free	25	free
31215-1	Asbestos, yarns, wholly or in part of asbestos, for use in manufacture of clutch facings and brake linings	7½	7½	25	5
31225-1	Asbestos felt, rubber impregnated for use in mcf floor coverings	free	free	25	free
31200-1	Asbestos, in any form other than crude, and all manufactures thereof, nop	15	22½	25	8
31205-1	Asbestos in any form other than crude, and all manufactures thereof, when made from crude asbestos of British Commonwealth origin, nop	free	12½	25	free
31220-1	Asbestos woven fabric, wholly or in part of asbestos for use in manufacture of clutch facings and brake linings	12½	12½	30	8

United States

Item No.			On and after Jan. 1, 1970	On and after Jan. 1, 1971	On and after Jan. 1, 1972
518.11	Asbestos, not manufactured, crude, fibres, stucco, sand and refuse containing not more than 15 per cent by weight of foreign matter	free			
			(%)	(%)	(%)
518.21	Asbestos, yarn, slivers, rovings, wick, rope cord, cloth, tape and tubing		5.5	4.5	4
518.51	Asbestos articles not specifically provided for		6	5	4.5
	Articles in part of asbestos and hydraulic cement		(¢ per lb)	(¢ per lb)	(¢ per lb)
518.41	Pipes and tubes and fittings thereof		0.2	0.18	0.15
518.44	Other		0.15	0.1	0.1

Sources: The Custom Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa, Tariff Schedule of the United States, Annotated (1976) TC Publication 749.

Canadian production is expected to return to a near-normal level in 1976, however the predicted movement out of recession by major industrial nations and the need to replenish depleted inventories will continue to strain the capacity of the industry.

The short-supply situation will be accentuated by the expected closure in 1978 of Cassiar's Clinton Creek mine which produces about 100,000 tons of asbestos fibre a year. This closure is expected to occur before the present prospective Canadian producers are capable of reaching the production stage and could result in a shortage of asbestos in world export markets of over 400,000 tons by 1980.

More emphasis will continue to be placed on improved monitoring of the health of workers and on stricter environmental controls inside and outside of plants.

If glass fibres can be made alkali-compatible these could replace, or partially replace, asbestos in some asbestos-cement products. No satisfactory substitutes are available for asbestos in many applications, particularly for friction materials.

Prices

Quebec producers raised prices three times in 1975, for a total of approximately 38 per cent. A split-price system prevailed among Quebec producers for several months because companies alternated price leadership roles as a result of marketing disruptions during the strike in Quebec. Cassiar prices also increased and remained essentially in line with those of Quebec producers.

Barite and Celestite

G.O. VAGT

In Canada, production of barite in 1975 was 89,680 tons*, an increase of approximately 4 per cent compared with the 1974 production of 86,001 tons. Imports of barium carbonate, one of the most important barium chemicals mainly derived from barite, amounted to 1,695 tons valued at $354,000 in 1975.

Barite ($BaSO_4$) is a valuable industrial mineral because of its weight (specific gravity 4.5) and chemical inertness. Its dominant use is as a weighting agent in muds that serve to counteract high pressures under the substrata when drilling oil and gas wells.

Barite is found in many countries of the world. The United States, the principal producer with about 23 per cent of the total production, is followed by West Germany with about 7 per cent of the total. Canada is tenth in world production and exports 56 per cent of its output, mainly as crude barite, to grinding plants in the United States.

Production and occurrences in Canada

Barite is found in a variety of geological environments: as the principal mineral in veins along with fluorite, calcite and quartz; as a gangue mineral in some lead-zinc-silver deposits; and as irregular replacement deposits in sedimentary rocks. Pure barite is white and is most common in veins; impure barite may be near white, grey, brown or light red. Barite was produced only in Nova Scotia, Ontario and British Columbia in 1975.

At the Walton, N.S. mine, operated by Dresser Minerals, a Division of Dresser Industries, Inc., most of the production was obtained from low-grade stockpiles, waste dumps and the tailings pond. Limited quantities of ore are still mined from underground workings, although mud and water inflows have not been effectively controlled. Prior to flooding, the barite ore was mined from a large replacement deposit by a block-caving method and hoisted through the same shaft as a lead-zinc sulphide ore mined in conjunction with the barite. Most of the production in 1975 was shipped in crude form to the southwestern United States and the remainder was transferred to an affiliated company for use in offshore oil drilling in eastern Canada.

There were two barite producers in British Columbia in 1975. Baroid of Canada, Ltd. recovered barite from tailings at an abandoned lead-zinc mine near Spillimacheen, south of Golden. The tailings were fed as a slurry to separation tables, and the barite concentrate dewatered and shipped by rail for further processing in a grinding plant at Onoway, Alberta. Mountain Minerals Limited mined barite underground from vein deposits near Parson and Brisco in the eastern part of the province, and recovered crude barite from the tailings at the Mineral King mine near Invermere. The crude barite was shipped to the company's plant at Lethbridge, Alberta for grinding.

Extender Minerals of Canada Limited produced at less than full capacity in 1975 after initiating production in 1974. Extender's new mine is located near Matachewan, Ontario, where barite is mined from a vein deposit by open-pit methods, with all beneficiation being done on the site.

There are many occurrences of barite across Canada. Of note are occurrences at Buchans, Newfoundland where there is an estimated 0.5 million tons of barite in tailings; in Nova Scotia near Brookfield on the mainland, and east of Lake Ainslie on Cape Breton Island; in northern Ontario in Yarrow, Penhorwood and Langmuir townships, and on McKellar Island in Lake Superior; at mile 397 in northern British Columbia, and north of mile 548 on the Alaska Highway. The Lake Ainslie deposit on Cape Breton Island contains about three million tons of ore grading 44 per cent barite and 17 per cent fluorspar. Feasibility studies to date have not developed an efficient commercial-scale separation method for this deposit.

Barite deposits in the MacMillan Pass region of the eastern part of the Yukon Territory continued to be evaluated by several companies.

* The short ton of 2,000 pounds is used throughout unless otherwise stated.

Table 1. Canada barite production, trade and consumption, 1974-75

	1974		1975p	
	(short tons)	($)	(short tons)	($)
Production (mine shipments)	86,001	978,444	89,680	1,083,000
Imports				
United States	12,281	779,000	4,937	485,000
People's Republic of China	550	4,000	—	—
India	39	4,000	—	—
France	3	. . .	—	—
Total	12,873	787,000	4,937	485,000
Exports				
United States	28,515	369,000	50,272	794,000
Venezuela	5,937	66,000	—	—
Emirates, U.A.	4	. . .	—	—
Total	34,456	435,000	50,272	794,000
	1973r		1974	
Consumption[1]				
Well drilling	73,283e		56,793e	
Paints and varnish	1,978		2,366	
Glass and glass products[2]	7,166		4,606	
Rubber goods	137		159	
Other[3]	584		494	
Total	83,148		64,418	

Source: Statistics Canada.
[1]Available data reported by consumers and estimates by the Mineral Development Sector, Department of Energy, Mines and Resources, Ottawa. [2]Includes glass fibre and glass wool. [3]Other includes ceramics, chemicals, plastics and brake linings.
pPreliminary; — Nil; . . . Less than $1,000; rRevised. eEstimate.

Uses, consumption and trade

The dominant use for barite is as a weighting agent in oil and gas well drilling muds where its specific gravity assists in counteracting high pressure in oil and gas reservoirs. Principal specifications are usually a minimum specific gravity of 4.25, a particle size of at least 90 per cent minus 325 mesh, and a maximum of 0.1 per cent water-soluble solids.

In 1974, apparent consumption of barite in Canada was estimated to be 64,418 tons, based on an estimated 56,793 tons utilized in the oil well drilling industry.

Barite is used in paint as a special filler or "extender pigment". This is a vital constituent that provides bulk, improves consistency of texture, surface characteristics and application properties, and controls prime pigment settling and the viscosity of paints. Specifications for barite used in the paint industry call for 95 per cent $BaSO_4$, particle size at least minus 200 mesh, and a high degree of whiteness or light reflectance.

The glass industry uses barite to increase the workability, act as a flux, assist decolouration and increase the brilliance or lustre of glass. Specifications

Table 2. Canada, barite production, trade and consumption, 1966-75

	Production[1]	Imports	Exports	Consumption[2]
	(short tons)			
1966	221,376	4,165	199,054	26,500
1967	172,270	5,924	146,103	32,000
1968	138,059	7,901	116,491	29,500
1969	143,230	6,243	108,610	41,000
1970	147,251	7,526	99,544	55,200
1971	120,765	11,332	73,879	58,200
1972	77,261	24,623r	20,188	78,900
1973	101,580	31,580	50,012	83,148r
1974	86,001	12,873	34,456	64,418r
1975p	89,680	4,937	50,272	. .

Source: Statistics Canada.
[1]Mine shipments. [2]Includes estimates by the Mineral Development Sector, Department of Energy, Mines and Resources, Ottawa.
pPreliminary; . . Not available; rRevised.

call for a minimum of 98 per cent $BaSO_4$ in the additive, not more than 0.15 per cent Fe_2O_3, and a particle size range of 40 to 140 mesh. Consumption of barite in the glass industry, including glass fibre and glass wool, amounts to the largest percentage of total consumption, next to well-drilling uses.

The specifications vary for natural barite used as a filler in rubber goods, but the main factors are whiteness and particle size range.

The balance of Canada's barite was used in the manufacture of ceramic products, chemicals, plastics and brake linings.

There is, as yet, no barium chemicals industry in Canada. Barium chemicals include: barium carbonate, which is the most important; chemical or precipitated barium sulphate, referred to in the trade as blanc fixe; and lithopone, a chemically precipitated mixture of 70 per cent barium sulphate and 30 per cent zinc sulphide. Lithopone is a white pigment that has been largely replaced by titanium dioxide pigments. Specifications of barite for the barium chemicals industry call for 95 per cent $BaSO_4$, and not more than 2 per cent Fe_2O_3.

World review

There is worldwide production and considerable international trade in barite even though transportation costs in some cases may be greater than the cost of the lump material. World production of barite in 1975 is estimated at 4.57 million tons, of which an estimated 75 per cent was consumed in oil-well-drilling operations. Dependence on the oil industry as a principal market means that demand is subject to considerable fluctuations as the tempo of oil and gas exploration varies in time and in geographic location. Conversely, oil and gas exploration takes place throughout the world, resulting in consistent world demand that is most economically served by production from many countries. The viability of any deposit is dominantly influenced by transportation costs to markets.

The United States is by far the world's largest producer of barite. About 40 mines produced an estimated 1.1 million tons, derived mostly from Nevada, Arkansas and Missouri, with smaller amounts from other states. Annual imports of barite to the United States are generally between 500,000 and 700,000 tons. Following the United States with 23.3 per cent of the total tonnage produced were West Germany (6.9); Ireland (5.8); Mexico (5.8); Peru (5.0); Italy (4.1); France (2.3); Greece (2.0); Morocco (2.2); Canada (2.0); Yugoslavia (1.5); other free world countries (19.8) and communist countries, except Yugoslavia, (19.3).

The United States, the principal consumer of barite, used 1.5 million tons in 1975. Imports into the United States for the years 1971 to 1974, inclusive, came from Ireland, 27 per cent; Peru, 26 per cent; Mexico, 20 per cent and other, 27 per cent. Of the total consumption of barite in the U.S., 83 per cent was used in oil-and gas-well drilling. The pattern of consumption of ground barite (excluding the barium chemicals industry) in the United States is similar to that in Canada.

In Ireland, Milchem (U.K.) Ltd. and Imco Drilling Services are developing properties. Also, Dresser Minerals worked on modifications to its grinding plant at Foynes.

Table 3. World mine production 1973-75 and reserves of barite 1975

	Mine production (000 short tons)			Reserves (000 short tons)
	1973	1974	1975[e]	
United States	1,104	1,106	1,066	65,000
Canada	102	86	90	4,000
France	110	110	106	4,000
West Germany	360	329	316	7,000
Greece	87	94	90	4,000
Ireland	276	275	264	6,000
Italy	183	196	188	5,000
Mexico	281	275	264	4,000
Morocco	113	103	99	6,000
Peru	243	240	230	4,000
Yugoslavia	68	72	69	3,000
Other free world countries	835	942	904	55,000
Communist countries (except Yugoslavia)	896	922	884	33,000
World totals	4,658	4,750	4,570	200,000

Source: United States Bureau of Mines, Commodity Data Summaries, January 1976 and United States Bureau of Mines, Mineral Trade Notes, Vol. 72, No. 12, December 1975.
[e] Estimated.

New grinding plants were completed in Indonesia by Milchem (U.K.) Ltd. and by Baroid Division of N L Industries Inc. Dresser Minerals completed construction of new grinding plants in Western Australia and southern Thailand.

At the Goonga mines near Khuzdar, Pakistan, Pakistan Petroleum Ltd. and the provincial government of Baluchistan signed an agreement to mine barite that will be used mainly by oil-well drilling companies in the Persian Gulf. Production is expected to be about 80,000 tons by 1980.

In France, the Rossignal mine, located 50 kilometers southwest of Chateaurous and developed by Société des Mines de Garrot and the Bureau de Recherches Géologiques et Minières (BRGM), is expected to produce about 140,000 tons of concentrates that will be consumed mainly in European chemical markets.

In the United States, Dresser Minerals and Milchem (U.K.) Ltd. completed construction of grinding plants at Galveston, Texas, and Mineral Point, Mississippi, respectively. Imco Drilling Services started construction of a grinding plant and a beneficiation plant, both near Battle Mountain, Nevada. Also, a jig plant was constructed in Crescent Valley, Nevada, to process ore from a nearby property owned by Imco.

Outlook

Increased oil exploration activity throughout the world assures that the demand for barite will continue strong for several years. World barite production may be expected to meet requirements because geologic factors suggest that there is good potential for discovery and development of deposits near most regions where there is drilling activity.

Exploration for new barite deposits in Canada and feasibility studies presently under way could bring about changes in the production pattern and the quantity of output in the near future. Continued oil-and gas-well drilling activity in the Mackenzie Delta, Arctic regions, and off the east coast of Canada suggests a growing market for barite in these areas.

In the future larger quantities of barite may be recovered from mine dumps and tailings ponds in Canada and abroad. Also, an increasingly important source of barite may be as a co-product from the mining of iron, base-metal, fluorspar and rare-earth ores.

The relatively low cost and technical advantages of barite for the drilling-mud market suggests that other materials will not likely be substituted in this major application. For example; iron ore is more abrasive and undesirable to handle because of colour, celestite ($SrSO_4$) is more expensive and has a lower specific gravity, and galena (PbS) is too expensive.

Prices

United States prices of barite according to Engineering and Mining Journal of December, 1975.

	($ a ton)
Chemical and glass grade	
Hand picked, 95% $BaSO_4$	
not over 1% Fe	40-60
Magnetic or flotation, 96%	
$BaSO_4$ not over 0.5% Fe	45-50
Imported drilling-mud grade,	
specific gravity 4.20-4.30 cif	
Gulf ports	19-28
Canada	19
Ground	
Water, 99½% $BaSO_4$	
325 mesh, 50-lb bags	60-80
Dry ground drilling-mud grade,	
83-93% $BaSO_4$ 3-12% Fe,	
specific gravity 4.20-4.30	71-78
Imported	
4.20-4.30 specific gravity	31

Tariffs

Canada

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
		(%)	(%)	(%)	(%)
49205-1	Drilling-mud and additives	free	free	free	free
68300-1	Barites	free	10	25	free
92842-1	Barium carbonate	10	15	25	10
92818-1	Barium oxide, hydroxide peroxide	10	15	25	10
93207-5	Lithopone	free	12½	25	free

United States

Item No.			On and After January 1, 1972
472.02	Barium carbonate, natural, crude	free	
472.04	Barium carbonate, natural, ground		6%
			($ per lt)
472.10	Barium sulphate, natural		1.27
472.12	Barium sulphate, natural, ground		3.25
			(¢ per lb)
472.14	Barium sulphate, precipitated (blanc fixe)		0.3
473.72	Lithopone, containing under 30% zinc sulphide		0.43
473.74	Lithopone, containing 30% or more zinc sulphide		0.43+ 3.5

Sources: For Canada, the Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa. For the United States, Tariff Schedules of the United States, Annotated (1976) TC Publication 749.

CELESTITE

Celestite ($SrSO_4$), the main source of strontium, is used to produce commercial strontium compounds, principally strontium carbonate and strontium nitrate. In the sulphate form it is used in the zinc flotation process. Strontium carbonate is used in glass faceplates in colour television sets, where it improves the absorption of X-rays emitted by picture tubes operated at high voltages. An increasing use for this compound is in the manufacture of ferrites, a material required in the production of ceramic permanent magnets, which are used in small electrical motors.

Kaiser Celestite Mining Limited, a subsidiary of Kaiser Aluminum & Chemical Canada Investment Limited, and Canada's only producer of celestite, mined celestite ore from an open pit near Loch Lomond, Cape Breton Island, N.S. Concentrate was produced from a flotation mill at the mine site. The concentrate was shipped to the Point Edward, Nova Scotia plant of Kaiser Strontium Products Limited, for treatment with imported natural sodium carbonate to produce technical-and chemical-grade strontium carbonate, commercial-grade strontium nitrate and sodium sulphate. Capacities of the plants are: 225 tons of $SrSO_4$ concentrate a day from the mill, 90 tons a day of $SrCO_3$, and up to 100 tons a day of sodium sulphate. There is capacity at the Point Edward chemical plant to produce small quantities of strontium nitrate, used in pyrotechnics and tracer ammunition. Operating problems and cost overruns were associated with the new plant and newly developed process.

Consumption uses have not developed as rapidly as anticipated and recent developments indicate that Kaiser does not plan to continue operation of the mine and chemical plant beyond 1976.

Current producers of strontium carbonate in the United States obtain their celestite from Mexico.

Prices

United States prices according to Chemical Marketing Reporter, December, 1975.

Strontium carbonate	($ per pound)
technical grade, bags carlot, truckload, works	.18-.25
Strontium nitrate	($ per 100 pounds)
bags, carlot, works	24.00

Tariffs

Canada

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
92839-5	Strontium nitrate effective July 1, 1974 to June 30, 1984	free	free	free	free

United States

Item No.		On and After January 1, 1973
Strontium Metal		
632.46	Unwrought, waste and scrap	5%
632.68	Alloys of strontium	7.5%
473.19	Strontium chromate pigments	5%
Strontium Compounds		
421.70	Carbonate	free
421.72	Carbonate (precipitated)	6%
421.74	Nitrate	6%
421.76	Oxide	6%
421.82	(mineral celestite)	free
421.84	Sulphate	5%
421.86	Other	5%

Sources: For Canada, The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division. For United States, Tariff Schedules of the United States, Annotated (1976) TC Publication 749.

Bentonite

G.O. VAGT

Bentonite is a clay composed mainly of the mineral montmorillonite, a member of the smectite group of clay minerals. The term "smectite", as a group name, is growing in acceptance and this usage eliminates confusing terminology that includes "montmorillonite" as both mineral species and group names. Montmorillonite is a hydrated aluminum silicate with weakly-attached cations of sodium and calcium which impart different properties to bentonite depending on amounts and proportions present. In general, the properties of clays are complex; understanding their behaviour under certain conditions is complicated by their extremely fine particle size and, in the case of bentonite, is more complicated by cation exchange and the swelling capacity of the clays. One method of classifying bentonite is based on this swelling capacity when wet. With sodium as the dominant or abundant exchangeable ion, swelling from 15 to 20 times the original dry volume will occur, and when added to water, gel-like masses result. Sodium bentonite also possesses a high dry-bonding strength, especially at high temperatures, a feature important in the manufacture of some ceramic products.

Montmorillonite clays have high ion-exchange properties and, by adsorption, absorption and chemical activity, bentonite can collect many types of inorganic and organic compounds, sometimes selectively. In general, the non-swelling or calcium bentonites exhibit the more pronounced adsorptive characteristics. While naturally-occurring clays may exhibit adsorptive or bleaching properties, their efficiencies are commonly improved by acid leaching or, as the process is generally termed, activation.

Another clay, "fuller's earth", also contains mainly smectite-group clay minerals and is very similar to non-swelling bentonite. These clays have natural bleaching and absorbent properties and were originally used by fullers to remove dirt and oil from wool. The terminology is confusing, and bentonite and fuller's earth may or may not be separated in world trade and production figures by country.

Bentonites may originate from smectitic clays formed from igneous rocks other than volcanic ash, tuff or glass, or from rocks of sedimentary or uncertain origin. The deposits occur in relatively flat-lying beds of various chemical compositions and impurities; the latter consisting of quartz, chlorite, biotite, feldspar, pyroxenes, zircon and various other minerals. Natural clay may be creamy white, grey, blue, green or brown; and, in places, beds of a distinctly different colour are adjacent. Fresh, moist surfaces are waxy in appearance; on drying, the colour lightens, and the clay has a distinctive cracked or crumbly texture.

Production and occurrences in Canada

Canadian bentonite occurrences are confined to Cretaceous and Tertiary rocks at many localities in Manitoba, Saskatchewan, Alberta and British Columbia. Although clay beds occur in rocks older than Cretaceous, none of these in Canada have been identified as bentonite.

Three companies mine and process bentonite in Canada, but statistics on total production and exports are not available for publication.

In Alberta, Dresser Minerals Division of Dresser Industries, Inc. recovers swelling bentonite from the Edmonton Formation of Upper Cretaceous age. The deposits are in the Battle River Valley, nine miles south of Rosalind, the site of the company's processing plant. Baroid of Canada, Ltd. mines a similar bentonite from the same formation, about 14 miles northwest of the company's processing plant and rail siding at Onoway.

Bentonite is mined selectively from relatively shallow paddocks or pits in the dry summer months. Some natural drying may be done by spreading and harrowing material before trucking it to plants for further processing. Both companies dry, pulverize and bag the bentonite. Swelling bentonite from Alberta is used mainly as a drilling-mud additive, a foundry clay, as feed pelletizing material, as a fire-retardant additive to water and as a sealer for farm reservoirs.

In Manitoba, Pembina Mountain Clays Ltd. mines non-swelling bentonite from the Upper Cretaceous Vermilion River Formation, 19 miles northwest of Morden, which is 80 miles southwest of Winnipeg. Some bentonite is dried and pulverized in a plant at

Morden, but the bulk of production is railed from Morden to the activation plant at Winnipeg, where it is leached, washed, filtered, dried, pulverized and bagged. The main use is for decolourizing and purifying mineral and vegetable oils, animal fats and tallows.

Inland Cement Industries Limited is studying the feasibility of large-scale production of sodium bentonite from its deposit in the Avonlea "bad lands" near Truax, Saskatchewan. Limited quantities are produced and marketed now and this product could replace appreciable amounts of imported Wyoming bentonite required for iron-ore pelletizing.

Uses, consumption and trade

Bentonite has many uses, but it generally constitutes only a small part of the final product.

Select swelling bentonite has found widespread and rapidly growing uses as a binder in the pelletizing of iron mineral concentrates. About 18 pounds is used in every long ton of concentrate to provide the pellet with sufficient "green" strength to withstand handling during the drying and firing stages. The amount of bentonite required varies with the mineralogy and particle size of the concentrate. Approximately 70 per cent of the reported total consumption of bentonite in 1974 was used in pelletizing iron-ore concentrates.

Special muds used in oil- and gas-well drilling contain about 10 per cent swelling bentonite, which is used principally to prevent the loss of drilling fluid into permeable zones by coating the wall of the drillhole with a gel. It also serves as a lubricant and helps to keep the drill cuttings in suspension.

Table 1. Canada, bentonite imports and consumption, 1974-75

	1974		1975p	
	(short tons)	($)	(short tons)	($)
Imports				
Bentonite				
United States	245,904	3,353,000	202,631	3,706,000
Greece	44,587	594,000	64,231	1,083,000
Total	290,491	3,947,000	266,862	4,789,000
Activated clays and earths				
United States	20,404	2,491,000	9,333	2,803,000
Greece	69,409	1,058,000	38,336	1,418,000
France	152	71,000	621	262,000
Other countries	23	11,000	69	28,000
Total	89,988	3,631,000	48,359	4,511,000
Fuller's earth				
United States	9,486	289,000	2,021	88,000
		1972	1973r	1974p
		(short tons)	(short tons)	(short tons)
Consumption[1] (available data)				
Pelletizing iron ore		209,274	263,408	220,486
Well drilling		11,022	24,740	10,839
Foundries		42,625	55,743	83,256
Chemicals		25	25	43
Fertilizer stock and poultry feed		732	172	835
Paint and varnish		286	338	708
Pulp and paper		179	130	–
Other products[2]		12,579	1,175	1,564
Total		276,722	345,731	317,731

Source: Statistics Canada.
[1]Does not include activated clays and earths. Breakdown by Mineral Development Sector, Department of Energy, Mines and Resources, Ottawa. [2]Explosives, frits and enamels, refactory brick and cements, ceramic products, petroleum and vegetable oils refining and other miscellaneous minor uses.
pPreliminary; rRevised.

Table 2. Canada, bentonite imports[1] and consumption[2], 1966-75

	Imports		Consumption
	(short tons)	($)	(short tons)
1966	204,038	2,606,000	169,692
1967	235,451	3,346,000	189,155
1968	323,093	4,041,000	222,011
1969	311,327	4,638,000	265,765
1970	386,984	5,590,000	289,692
1971	370,146	5,357,000	278,543
1972	349,883	5,912,000	276,722
1973	418,820	8,215,000	345,731r
1974	389,965	7,867,000	317,731
1975p	317,242	9,388,000	. .

Source: Statistics Canada.
[1]Includes bentonite, fuller's earth and activated clays and earths. [2]Includes only fuller's earth and bentonite.
pPreliminary; . . Not available rRevised.

Swelling bentonite serves as a binder in moulding sands used by iron and steel foundries. Non-swelling bentonite is also used as a binder in some low-temperature foundries.

Swelling bentonite is used as a binder in the pelletizing of base-metal concentrates and stock feeds. It is used in small quantities as a plasticizer in abrasive and ceramic mixes; as a filler in paints, paper, rubber, pesticides, cosmetics, medicinal products, and cleaning and polishing compounds; in the grouting of sub-surface water-bearing zones; and in the sealing of dams and reservoirs. Bentonite slurry is effective in fighting forest fires and in retaining the walls of excavations prior to the placement of concrete or other structural materials.

Some non-swelling bentonite is used in pelletizing stock feed, as a carrier for pesticides, and as a cleaning powder for animals.

Activated bentonite is used in decolouring mineral and vegetable oils, animal fats, waxes, beverages and syrups. It is also used in some countries as a catalyst in the refining of fluid hydrocarbons.

Consumption of bentonite in Canada increased greatly in the last decade (see Table 2), largely because of increased consumption as a binder in iron concentrate pelletizing, as more of these plants have been constructed. Consumption of bentonite in well drilling in the oil and gas industry is subject to considerable fluctuation. Iron and steel foundries require bentonite as a binder for moulding sands and consumption for this use is continuing to rise. Relatively minor quantities of activated clays and fuller's earth are imported mainly from the United States, and some activated bentonite from Manitoba is exported to the United States.

Bentonite production in the United States is centred on extensive deposits in Wyoming where the name was derived from the Cretaceous Fort Benton Formation. These Cretaceous deposits are the world's outstanding swelling bentonite occurrences, and the specifications and standards for bentonite used in industry are based on these high-quality clays. Although there are numerous occurrences of bentonite in many countries it is mined in only a few. Because of the high standards of Wyoming bentonite this material is transported over such long distances that transportation costs commonly exceed the value of the product at the mine, in some cases by several times. However, in recent years, Wyoming producers have lost some markets for iron-ore pelletizing in eastern Canada to Greek bentonite producers. The cost spread between rail and ocean transportation is the principal reason for this change. Canada is the main importer from the United States, which also ships some bentonite to Australia and western Europe.

Non-swelling bentonite, fuller's earth, and bleaching clays are produced in numerous states, the major ones being Florida, Georgia, Mississippi and Texas.

Outlook

The bulk of Canada's bentonite consumption is used in pelletizing iron-ore concentrates. At present, the most suitable material for this purpose is imported from the United States. The slowdown in import growth since 1970 is attributed to a more-stable consumption pattern resulting from the completion of new pellet plants. Sidbec-Dosco Limited at Port Cartier, P.Q. has a projected 6-million-ton-a-year iron ore pellet plant to process concentrate from its Fire Lake property. The project should reach maximum capacity output by 1978 and it is anticipated that this plant alone will increase bentonite consumption by 15 per cent to 20 per cent in the next three years. No changes in production and consumption in industries other than ore pelletizing are foreseen.

Prices

United States bentonite prices quoted in Chemical Marketing Reporter, December 29, 1975.

	($)
Bentonite, domestic, 200 mesh, bags, car lots, fob mines, per ton	15.50-16.00
Bentonite, imported Italian white, high gel, bags, 5-ton lot ex-warehouse, per lb.	.1688

Tariffs

Canada

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
29500-1	Clays, not further manufactured than ground	free	free	free	free
93803-2	Activated clay	10%	15%	25%	10%
20600-1	Fuller's earth, in bulk	free	free	free	–

United States

Item No.		On and After Jan. 1, 1972
		(¢ per long ton)
521.61	Bentonite	40
521.51	Fuller's earth not beneficiated	25
521.54	Wholly or partly beneficiated	50
		(¢ per lb)
521.87	Clays, artificially activated with acid or other material	0.05 +6% ad valorem

Sources: The Custom Tariff and Amendments, Department of National Revenue, Custom and Excise Division, Ottawa. Tariff Schedules of the United States, Annotated (1976), T.C. Publication 749.
– Nil.

Bismuth

G.R. PEELING

Bismuth is obtained in Canada in the processing of some lead-zinc, lead-zinc-copper and copper ores. The more important sources are the lead-zinc-copper ores mined in New Brunswick and the lead-zinc ores mined in southeastern British Columbia. Smaller amounts are recovered from ores mined in Ontario and Quebec. Bismuth is also recovered from the flue dusts at the copper smelter of Gaspé Copper Mines, Limited in Quebec. The dusts are then shipped to Brunswick Mining and Smelting Corporation Limited in New Brunswick for refining.

Bismuth production in Canada in 1975, based on bismuth recovered from domestic ores and concentrates plus the bismuth content of bullion and concentrates exported, was 345,254 pounds valued at $2,646,596. This represents a 41 per cent increase in production from the level of 244,726 pounds in 1974. Inventory of metallic bismuth held by consumers as of December 31, 1975 totalled 9,175 pounds, down from 14,098 pounds held at year-end 1974.

In 1975, world production of bismuth as estimated by the United States Bureau of Mines, excluding United States production, was about 8.9 million pounds, an increase of 1.8 per cent from the 8.8 million pounds in 1974. Japan was the leading producer, with an output of 1.7 million pounds, followed by Bolivia, Peru and Mexico. The United States which is a substantial producer from its own and imported ores does not publish production statistics because one company accounts for almost all of the country's refined metal output.

The bismuth market, coming off a weak second half in 1974, continued to decline through 1975. Production, consumption and prices declined, while inventories increased.

In the United States consumption was down 38 per cent from 1974 with fusible alloys showing the largest drop — 46 per cent. The other two major users also showed significant declines in consumption, with pharmaceuticals dropping 34 per cent and metallurgical alloys dropping 38 per cent. The General Services Administration did not sell any bismuth from the government stockpile in 1975, leaving 2,100,004 pounds at year-end. The stockpile objective is 95,900 pounds but Congressional approval is needed before any of the 2,004,104 pounds of excess can be released.

Production of bismuth in Japan declined 7.5 per cent to 1.7 million pounds in 1975 from 1.8 million pounds in 1974. Inventories were reported to be about 300,000 pounds at the end of 1975, a significant increase over the 1974 level.

In Australia the major bismuth producer, Peko-Wallsend Ltd., had a difficult year and was forced to curtail many of its operations early in 1975 because of declining copper prices and increasing costs. The company was forced to close its Tennant Creek copper smelter and bismuth recovery plant early in the year because of the aforementioned reasons and technological problems. The plant has a capacity to recover about 1,300 tons of bismuth annually as crude bullion. It is not likely that the plant will reopen until sometime in 1977 and then only if copper prices are sufficient to warrant it. The company operates five mines in the Tennant Creek area, but operations at the Peko, Warrego, Gecko and Orlando mines were curtailed. The Juno mine continued production throughout the year but because of limited reserves it is expected to close in late 1976 or early 1977. Reserves for the five mines in 1975 are approximately 8.4 million tons grading 0.24 per cent bismuth on a weighted average basis.

Bolivia, traditionally a major supplier of bismuth, produced 1.47 million pounds in 1975 compared with 1.43 million pounds in 1974. Bolivia also became an important producer of refined bismuth in 1975 when Corporacion Minera de Bolivia (Comibol) opened its bismuth refinery with an annual capacity of 660 tons of 99.99 per cent bismuth near Telemayu. Prior to completion of the plant Comibol shipped bullion grading 20 per cent bismuth to Europe for refining. The country's major deposits are located in the Tasna mining district, where some deposits grade up to 40 per cent bismuth.

Domestic sources

The smelting Division of Brunswick Mining and Smelting Corporation Limited produces bismuth metal at its plant at Belledune, about 25 miles northwest of

Bathurst, New Brunswick. Production of bismuth metal and various grades of bismuth-lead alloy in 1975 was substantially above the 53,317 pounds produced in 1974 but weak markets led to much of the metal being stockpiled in 1975. The Kroll-Betterton process is used to treat the desilverized lead bullion and produce a bismuth-lead-calcium-magnesium dross. The dross is then refined pyrometallurgically with chlorine to produce bismuth metal or alloy.

The other primary bismuth metal producer is Cominco Ltd. at its lead-zinc plant in Trail, British Columbia. Cominco derives most of its output from lead concentrates produced at its Sullivan lead-zinc mine at Kimberley. Other sources included lead concentrates from other company mines and custom shippers, both domestic and foreign. Lead bullion produced from the smelting of these concentrates contains about 0.05 per cent bismuth. Bismuth is recovered as 99.99 + per cent metal from the treatment of residues resulting from the electrolytic refining of the lead bullion. Bismuth for use in research and the electronics industry is further processed at the company's nearby high-purity plant to give it a purity of up to 99.9999 per cent. Production in 1975 totalled 208,000 pounds compared with 220,000 pounds in 1974 (part of this production is derived from imported materials).

In the exploration and development field, Brunswick Tin Mines Limited, a subsidiary of the Sullivan Mining Group Ltd., completed metallurgical testing on ores from its Mount Pleasant property, about 40 miles north of St. Andrews in Charlotte County, New Brunswick. Ore reserves in the North Zone are estimated at 12.6 million tons and in the Fire Tower Zone at 30.0 million tons grading 0.2 per cent tungsten, 0.08 per cent bismuth and 0.08 per cent molybdenum. Metallurgical testing was completed in 1975 at the Department of Energy, Mines and Resources, Ottawa, and the encouraging results suggest that the major products can be successfully separated through a process involving gravity separation, flotation and leaching. Additional diamond drilling in 1975 has indicated two higher-grade zones within the Fire Tower Zone. Within these two zones bismuth grades are between 0.11 and 0.15 per cent. If the property is brought into production at a proposed milling rate of 1,500 tons a day, annual recoverable bismuth production could be in the order of 400,000 to 500,000 pounds.

Outlook

The outlook for 1976 is bleak; the major industrial economies appear to be recovering only very slowly from the depths of the recession reached in 1975. Consequently, the bismuth industry will be characterized by continuing high inventories, weak prices and slack demand in 1976.

The United States Bureau of Mines has forecast that bismuth consumption will grow at a rate of 1.4 per cent to 1980 and at a lower rate of 0.7 per cent from 1980 to 2000. Certainly the period 1976-77 will be one of more than adequate supply as markets are expected to remain long on metal.

In the 1976 to 1980 period, increases in production may come from Canada, Australia and the United States. For Australia and the United States, any increase in output of bismuth is dependent on a recovery in copper production, while in Canada it is mainly tied to the lead industry.

Table 1. Canada, bismuth production and consumption, 1974-75

	1974		1975	
	(lb)	($)	(lb)	($)
Production, all forms[1]				
British Columbia	74,320	609,275	42,247	261,931
New Brunswick	153,530	1,258,639	295,634	2,326,640
Ontario	16,169	132,553	5,378	42,325
Quebec	707	5,796	1,995	15,700
Total	244,726	2,006,263	345,234	2,646,596
Consumption, refined metal (available data)				
Fusible alloys and solders	4,836		5,101	
Other uses[2]	59,711		59,421	
Total	64,547		64,522	

Source: Statistics Canada.
[1]Refined bismuth metal from Canadian ores, plus recoverable bismuth content of bullion and concentrates exported. [2]Includes bismuth metal used in manufacture of pharmaceuticals and fine chemicals, other alloys and malleable iron.

Table 2. Canada, bismuth production, exports and consumption, 1966-75

	Production all forms[1]	Exports[2]	Consumption[3]
		(pounds)	
1966	525,659	. .	56,400
1967	668,476	. .	47,900
1968	648,232	. .	59,300
1969	579,059	. .	33,800
1970	590,340	. .	24,548
1971	271,196	. .	35,876
1972	275,029	. .	37,892
1973[4]	70,684[4]	. .	56,852
1974	244,726	. .	64,547
1975	345,254	. .	64,522

Source: Statistics Canada.
[1]Refined bismuth metal from Canadian ores, plus recoverable bismuth content of bullion and concentrates exported. [2]Refined and semi-refined bismuth metal. [3]Refined bismuth metal reported by consumers. [4]Incomplete statistical coverage.
. . Not available

Uses

A major use of bismuth is in pharmaceuticals, cosmetics and industrial and laboratory chemicals including catalytic compounds. Various bismuth compounds, salts and mixtures are used in pharmaceuticals for indigestion remedies, antacids, burn and wound dressings. Insoluble salts of bismuth are given to patients before X-ray examination of the digestive tract. Cosmetics containing bismuth oxychloride, which imparts a "pearlescent" glow to eye shadow, lipstick, nail polish and powders, comprise one of the larger end-use markets of bismuth, but consumption in this market depends on changing fashion trends and is declining.

Another important outlet for the metal is fusible or low-melting-point alloys for fire-protection devices, electrical fuses, fusible plugs and solders. Many of these alloys contain 50 per cent or more bismuth, with the chief additive metals being cadmium, lead and tin. In safety applications, the dependability of the melting temperatures of the various bismuth alloy compositions is of utmost importance. Pure bismuth metal expands 3.3 per cent on changing from a molten to a solid state. Nonshrinking, low-melting-point bismuth alloys are used in the holding of jet engine airfoil blades during the machining of the root sections. Bismuth-tin alloys are sprayed on patterns to make moulds in the plastic industry.

The metal is also used as an important additive to improve the machinability of aluminum alloys, malleable irons and steel alloys and, with indium, forms a low-melting alloy used in the ophthalmic industry for holding lenses. The United States Atomic Energy Commission uses bismuth in many nuclear research applications because of the metal's low thermal neutron absorption rate.

Table 3. Estimated world production of bismuth, 1973-75

	1973	1974	1975[e]
		(pounds)	
Japan (metal)	1,900,000	1,837,000	1,700,000
Bolivia	1,423,000	1,430,000[e]	1,475,000
Peru	1,262,000	1,470,000	1,400,000
Mexico	1,290,000	1,320,000[e]	1,300,000
Australia	930,000	936,000	1,100,000
People's Republic of China (in ore)	550,000	550,000	550,000
Republic of Korea (metal)	220,000	220,000[e]	230,000
Yugoslavia	121,000	220,000	220,000
Romania (in ore)	180,000	180,000	180,000
France (metal)	155,000[e]	155,000[e]	155,000
Canada	71,000[2]	245,000	345,000
Other countries	194,000	202,000	270,000
Total[1]	8,296,000	8,765,000	8,925,000

Sources: Statistics Canada for Canada; for remaining countries, U.S. Bureau of Mines, *Minerals Yearbook* Preprint 1974 and *U.S. Commodity Data Summaries*, January 1976.
[1]Total for listed figures only; it excludes United States production, which is not available for publication; as well as that of some other smaller producing countries. [2]Incomplete statistical coverage.
[e] Estimates by U.S. Bureau of Mines.

Bismuth is used in catalysts in the production of acrylonitrile for acrylic fibres and plastics. This use suffered some decline in the 1960s but technological improvements in the process have led to increased demand in the 1970s. The rubber industry also uses a bismuth compound to accelerate the vulcanization process.

Table 4. United States consumption of bismuth by principal uses

	1974	1975[p]
	(pounds)	
Fusible alloys	748,604	401,932
Other alloys	21,417	26,007
Pharmaceuticals[1]	838,134	553,313
Experimental uses	305	713
Metallurgical additives	668,932	416,200
Other uses	6,586	7,856
Total	2,283,978	1,406,021

Source: Mineral Industry Surveys, United States Department of the Interior, Bureau of Mines, *Bismuth in the First Quarter 1976*.
[1] Includes industrial and laboratory chemicals.
[p] Preliminary.

Prices

The Canadian price for bismuth, as quoted by Cominco Ltd., for bars 99.99 per cent pure in lots of one ton or more, was $9.00 a pound from January 1 to March 11 when the price was dropped to $7.50 a pound in response to a similar price move by the major producer in the United States. This price remained in effect for the rest of the year. The United States' price, in ton lots, as published in *Metals Week*, was U.S. $9.00 a pound until February 26, after which the price of $7.50 was in effect. Within three weeks of the U.S. price move in February, all the major producers in Canada, Bolivia, Japan and Australia posted similar prices. Dealer prices in the United States were more indicative of consumer interest in the metal during the year. Consumers for the most part lived off stocks acquired during 1974 and the resultant effect on the dealer price was to send it into a steady decline during the year. Quotes by dealers consistently ran about $1.75 to $2.40 a pound below the producer price level and at the end of the year were in the range of U.S. $5.00 to $5.50 a pound.

The major uses for bismuth are in fusible alloys, metallurgical applications and in bismuth salts, mainly in the pharmaceutical industry. Demand and consequent price levels in 1976 will depend on the state of the aircraft and automobile industries (the major outlets for the first two uses mentioned). The last mentioned use — pharmaceuticals — is more prone to substitution as the bismuth price goes up. If, as most experts predict, the economic recovery is protracted, there is little likelihood of a price improvement in 1976.

Prices

Canada

Canadian bismuth prices in Canadian currency, as quoted by Cominco Ltd. in 1975:

Bismuth metal — 99.99% pure, per lb., lots of 1 ton or more

January 1 — March 11	$9.00
March 12 — December 31	7.50

United States

United States bismuth prices in U.S. currency, as quoted in Metals Week in 1975.

Bismuth Metal, per lb.
Ton lots

January 1 — February 26	$9.00
February 27 — December 31	7.50

Tariffs

Canada

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
33100-1	Bismuth ores and concentrates	free	free	free	free
35106-1	Bismuth metal, not including alloys, in lumps, powders, ingots or blocks	free	free	25%	free

United States

601.66	Bismuth ores and concentrates	free
632.10	Bismuth metal, unwrought; waste and scrap, bismuth alloys	free
632.64	Containing by weight not less than 30% lead	free
		1972
632.66	Other	9
633.00	Bismuth metal, wrought	

Sources: The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa. Tariff Schedules of the United States Annotated (1976) TC Publication 749.

Cadmium

D.H. BROWN

Although cadmium is a relatively rare element in the earth's crust, it occurs most commonly as the sulphide, greenockite (CdS) which is found associated with zinc sulphide ores, particularly sphalerite [(Zn, Fe)S]. The presence of cadmium during sphalerite formation results in the formation of greenockite crystals on the surface and between the sphalerite crystals. To a very small degree cadmium also displaces zinc within the sphalerite crystal structure. The intimate association of cadmium with zinc minerals continues even during separation of multi-mineral ores into concentrates, such that small amounts of zinc reporting to lead and copper concentrates will be accompanied by a proportionate amount of cadmium. There are no known commercial reserves of cadmium and, accordingly, reserves at any time are a function of zinc reserves, and specifically the cadmium content of those reserves. Cadmium recoveries are generally estimated to be 70 to 90 per cent from ore to concentrate and 45 to 75 per cent from concentrate to metal, or 31.5 to 67.5 per cent overall.

Cadmium metal is recovered only as a byproduct of zinc smelting and refining and since secondary sources are considered negligible in terms of total supply, cadmium production or supply is therefore strictly a function of zinc metal production, which bears little or no relationship to the demand for cadmium. Because cadmium represents only 2 to 3 per cent of zinc plant revenues, its supply is virtually inelastic to price fluctuations.

Generally, cadmium is recovered in fumes collected during the roasting of zinc-bearing ores and concentrates, or in precipitates obtained during the purification of zinc sulphate solution resulting from the sulphuric acid leaching of calcine which is the product of roasting. In Canadian zinc plants, which are all electrolytic, cadmium metal is next recovered either by the electrolytic process whereby the cadmium-bearing precipitate is redissolved in sulphuric acid and plated out in electrolytic cells, or by a purification process in which cadmium-bearing precipitates are releached in sulphuric acid, then filtrated and purified. The purified solution is then cemented with zinc dust to produce cadmium sponge which, in turn, is filtered, briquetted, melted and cast. At primary zinc distillation plants cadmium is reduced and vaporized with zinc in a retort or furnace. The vapour is condensed and cadmium (BP* 776°C) is separated from zinc (BP 905°C) by fractional distillation.

Production of cadmium metal in the western world during 1975 followed the 15 per cent decline in zinc metal production and is estimated to be 12,375 tons compared with 14,936 tons in 1974. Consumption, however, declined even further as indicated by world prices for cadmium that declined from over $4.00 per pound to less than $2.00 per pound during 1975 as supply built up during the year. Based upon a weighted average decline in consumption of 38 per cent from 1974 in the major consuming countries: the United States, 35 per cent; Japan, 54 per cent; Germany, 44 per cent; and the United Kingdom, 38 per cent; western world consumption in 1975 is estimated to be 9,405 tons, compared with 15,169 tons in 1974. In addition to the apparent stock increase of 3,293 tons, primary producers were further beset by reduced shipments as consumers liquidated stocks, resulting in a massive transfer of working stock levels to the primary producers. There were no sales of cadmium metal by the General Services Administration in the United States from the strategic stockpile which remained at about 3,224 tons, with about 1,001 tons surplus to the strategic level and available for sale.

In Canada, metal production increased to 1,422 tons in 1975 from 1,376 tons in 1974, and consumption is estimated to have decreased to 33 tons from 53 tons in 1974. Cadmium metal exports declined 29 per cent to 703 tons in 1975 from 944 tons in 1974. The United States and the United Kingdom remained Canada's major markets, accounting for 83 per cent of total exports, with the balance being shipped to Belgium, Germany and the Netherlands. Canada was the third-largest producer of cadmium in the western world in 1975, following Japan at 2,808 tons and the United States at 2,193 tons.

* Boiling point.

Canadian production

Canadian mine production in 1975, as reported by Statistics Canada, was 2,682,000 pounds, down 2 per cent from 1974. This figure represented the metallic cadmium recovered at domestic smelters from Canadian ores, plus the recoverable cadmium content of ores and concentrates exported. Canadian mines listed in Table 4 produced approximately 7.9 million pounds of cadmium in zinc concentrates in 1975 compared with 8.3 million pounds in 1974. The difference between data reported by Statistics Canada and that shown in Table 4 stems from the fact that many mining companies are not paid for their cadmium in concentrates and thus did not report it. For the same reason, most mines do not assay for cadmium on a regular basis and accordingly many of the productions shown in Table 4 are estimated composite assays of annual production. Metallic cadmium is recovered as a byproduct at the electrolytic zinc plants of Cominco Ltd. at Trail, British Columbia; Hudson Bay Mining and Smelting Co. Limited at Flin Flon, Manitoba; Canadian Electrolytic Zinc Limited at Valleyfield, Quebec; and Texasgulf Canada Ltd., near Timmins, Ontario. Metal production in 1975 increased to 1,422 tons equal to 6.0 pounds cadmium per ton of zinc metal produced, compared with 1,376 tons in 1974 equal to 5.9 pounds cadmium per ton zinc metal produced.

Table 1. Canadian primary cadmium statistics 1973-1975

	1973	1974	1975
		(tons)	
Mine production Cd content[e]	. .	4150	3891
Metal production	1595	1376	1422
Metal Consumption	60	53	33[e]
Metal Capacity	2010	2010	2010
Metal Exports	1630	994	703

Sources: Statistics Canada; published Company annual shareholders' reports.
[e]Estimates by Mineral Development Sector, Department of Energy, Mines and Resources, Ottawa.
. . Not available.

Newfoundland. The Buchans unit of ASARCO Incorporated and Newfoundland Zinc Mines Limited which commenced production June 29, 1975 are the only cadmium producers in the province. Production of cadmium in zinc concentrates in 1975 was 240,024 pounds. This should increase to about 350,000 pounds in the full production year of 1976.

New Brunswick. Of the three producers in the province only Nigadoo River Mines Limited has a sufficient grade of cadmium in concentrate to be payable, and which at 0.63 per cent is the second-highest grade in Canada. Production at the mine in 1975 was 127,232 pounds compared with a provincial total of 751,986 pounds contained in zinc concentrate.

Quebec. Canadian Electrolytic Zinc Limited produced 401,000 pounds of refined cadmium in 1975 compared with 772,000 pounds in 1974. Concentrates treated include those produced by Mattagami Lake Mines Limited, Orchan Mines Limited, Joutel Copper Mines Limited, the Geco Division of Noranda Mines Limited and Newfoundland Zinc Mines Limited. Except for Geco with its 0.41 per cent grade of cadmium in zinc concentrate, the other mines reported lower cadmium contents, thus accounting for the low 1973-1975 average yield of 4.4 pounds cadmium per ton of zinc metal produced. The new jarosite process planned for Canadian Electrolytic Zinc as part of the expansion program scheduled for 1976 should improve recoveries of cadmium. Lemoine Mines Limited will commence production at its new property near Chibougamau in 1976, with about 99,000 pounds of cadmium anticipated annually in zinc concentrates

Table 2. Canadian cadmium metal capacity and production, 1975

Company and Location	Production	Capacity	Capacity Utilization
	(pounds)	(pounds)	(per cent)
Canadian Electrolytic Zinc Limited, Valleyfield, Que.	401,000	1,200,000	33.4
Cominco Ltd., Trail, B.C.	1,364,000	1,460,000	93.4
Hudson Bay Mining & Smelting Co. Ltd., Flin Flon, Manitoba	139,698	360,000	38.8
Texasgulf Canada Ltd., Timmins, Ontario	940,000	1,000,000	94.0
Total	2,844,698	4,020,000	70.8

Sources: Published 1975 Company Annual Reports. Operators List 3, January 1975. Mineral Development Sector, Department of Energy, Mines and Resources, Ottawa.

produced. During 1975 two minor producers, Joutel Copper Mines Limited and Normetal Mines Limited, closed due to ore exhaustion, and a third, La Société minière Louvem inc., commenced production. Mine production in the province amounted to 695,241 pounds in 1975.

Ontario. Texasgulf Canada Ltd., at its Timmins plant produced 940,000 pounds of refined cadmium in 1975 compared to 782,000 pounds in 1974. The mine produced 2,530,743 pounds of cadmium making in the largest cadmium-producing mine in Canada. The good grade of 0.25 per cent cadmium in zinc concentrate produced at Timmins is a factor in the plant's high metal yield of 9.3 pounds of cadmium per ton of zinc metal produced during the 1973-75 period. Apart from the South Bay Division of Selco Mining Corporation Limited and the Geco mine mentioned previously, other Ontario mines are relatively small cadmium producers; however, in total the province had the largest mine output in Canada totalling 3,944,154 pounds of cadmium in zinc concentrate during 1975.

Table 3. Cadmium production, exports and consumption, 1974-75

	1974		1975^p	
	(pounds)	($)	(pounds)	($)
Production				
All forms[1]				
Ontario	1,680,019	6,681,436	1,519,000	4,056,000
British Columbia	432,062	1,718,310	752,000	2,008,000
Quebec	335,254	1,333,305	267,000	712,000
New Brunswick	71,630	284,873	70,000	187,000
Manitoba	174,449	693,784	56,000	151,000
Saskatchewan	32,422	128,942	9,000	25,000
Newfoundland	5,676	22,573	5,000	12,000
Yukon	4,358	17,331	4,000	11,000
Northwest Territories	—	—	—	—
Total	2,735,870	10,880,554	2,682,000	7,162,000
Refined	2,541,270		2,518,785	
Exports				
Cadmium metal				
United States	1,416,158	5,197,000	631,655	1,856,000
United Kingdom	546,480	2,187,000	543,271	1,584,000
Belgium and Luxembourg	—	—	98,485	243,000
West Germany	—	—	88,200	165,000
Netherlands	—	—	44,380	90,000
France	—	—	11	1,000
Senegal	—	—	100	. . .
Italy	22,000	83,000	—	—
Other countries	2,511	10,000	—	—
Total	1,987,149	7,477,000	1,406,102	3,939,000
Consumption (Cadmium Metal)[3]				
Plating	75,837		. .	
Solders	2,420		. .	
Other products[4]	27,291		. .	
Total	105,548		. .	

Source: Statistics Canada.
[1]Production of refined cadmium from domestic ores, plus recoverable cadmium content of ores and concentrates exported. [2]Refined metal from all sources and cadmium sponge. [3]Available data reported by consumers. [4]Mainly chemicals, pigments and alloys, other than solder.
^{p}Preliminary; — Nil; . . . less than $1,000; . . Not available

Manitoba and Saskatchewan. Cadmium mine production in these provinces is limited to Hudson Bay Mining & Smelting Co. Limited and Sherritt Gordon Mines Limited, both of which report a low grade of cadmium in zinc concentrate. The electrolytic zinc plant of Hudson Bay at Flin Flon treats concentrates produced in the two provinces and some shipped from the Northwest Territories. Production at the plant was 139,698 pounds of refined cadmium in 1975 compared with 298,736 pounds in 1974. The company reported stockpiling of five months cathode cadmium production in 1975 which reduced average cadmium yield to 3,4 pounds per ton zinc produced during the 1973-1975 period.

British Columbia. Metallic cadmium production at the Trail electrolytic zinc plant of Cominco Ltd. was 1,364,000 pounds in 1975 compared with a production of only 899,000 pounds in 1974 when there was a four-month labour strike. The plant treats concentrates produced at its Sullivan and H.B. mines as well as concentrates from the Pine Point mine in the Northwest Territories. Average cadmium yield during the 1973-1975 period was 5.7 pounds cadmium per ton of zinc produced. Collectively, mines in the province produced 834,522 pounds cadmium in zinc concentrate during 1975. The Annex mine owned by Reeves MacDonald Mines Limited closed March 31, 1975 due to ore exhaustion.

Yukon Territory. United Keno Hill Mines Limited and Cyprus Anvil Mining Corporation were the only mine producers of cadmium in zinc concentrate producing 347,218 pounds in 1975. Although production is small, United Keno has the highest cadmium grade in zinc concentrate in Canada at 0.73 per cent cadmium. Cyprus cadmium production is contained in both a zinc and bulk concentrate, but concentrations are very low.

Northwest Territories. Pine Point Mines Limited was the sole producer of cadmium in zinc concentrate in the Territories in 1975 with production of 602,894 pounds cadmium. In 1976 it will be joined by Nanisivik Mines Ltd. which will commence production at its Strathcona Sound Property on Baffin Island at an annual rate of about 644,000 pounds of cadmium per year.

Uses

Cadmium is a soft, ductile, silvery-white electropositive metal with a valence of two. It is used mainly for electroplating other metals or alloys; principally iron and, to a lesser extent, copper, to protect them against oxidation. A cadmium coating, like a zinc coating, protects those metals lower in the electromotive series by physical enclosure and by sacrificial corrosion. Cadmium is usually preferred to zinc as a coating because it is more ductile, is slightly more resistant to common atmospheric corrosion, can be applied more uniformly in recesses of intricately-shaped parts, and can be electrodeposited with less electric current per unit of area covered. It is also preferred for its more pleasing aesthetic appearance. Because it is more costly and much less plentiful than zinc, it is not as widely used. Improvement in zinc electroplating techniques in recent years have tended to reduce the consumption of cadmium in plating. Toxicity and environmental pollution are other factors that recently have contributed to lower consumption.

Cadmium-plated parts are used in the manufacture of automobiles, household appliances, aircraft, radios, television sets and electrical equipment. Plating accounts for about half the total consumption of cadmium.

The second-largest use is in the manufacture of pigments. Cadmium sulphides give yellow-to-orange colours and cadmium sulphoselenides give pink-to-red and maroon. Cadmium stearates act as stabilizers in the production of polyvinyl chloride plastics, and cadmium phosphors are used for tubes in both black-and-white and colour television sets. The use of cadmium compounds in recent years has expanded at a rate of 5 to 10 per cent annually and is now the largest potential growth area. Expansion in this use, which now accounts for about 35 per cent of cadmium consumption, has more than made up for reduced consumption in plating.

Cadmium is a valuable alloying metal and has applications in cadmium-silver solders and in cadmium-tin-lead-bismuth fusible or low-melting-point alloys for automatic sprinkler systems, fire-detection apparatus, and valve seats for high-pressure gas containers. Low-cadmium copper (about 1 per cent cadmium) is used in the manufacture of trolley and telephone wires because of the improved tensile strength imparted by cadmium. Low-cadmium copper is also now employed in automobile radiator finstock, replacing the low-silver copper formerly used. Another growing application is in the production of nickel-cadmium storage batteries. These batteries are considerably more expensive than the standard lead-acid battery, have a longer life and higher peak power output, are smaller, and are superior in low-temperature operation. They are especially suitable for use in airplanes, satellites and missiles, and ground equipment for polar regions, as well as in portable items such as battery-operated shavers, toothbrushes, drills and hand saws. Uses of cadmium in alloys account for about 15 per cent of cadmium consumption.

Prices

Typically, zinc plants pay for 60 per cent of the cadmium in zinc concentrates above a base level of 0.15 per cent cadmium equivalent to three pounds of cadmium per ton of zinc concentrate. Depending upon market conditions for cadmium and zinc concentrate, these payment terms can range from nothing to 70 per cent of the full cadmium content.

Table 4. Cadmium mine producers in Canada, 1975 and (1974)

Company and Location	Mill Capacity	Grade of Zinc Concentrates: Cadmium	Zinc	Lead	Copper	Silver	Zinc Concentrate Produced	Cadmium Content
	(tons ore/day)	(%)	(%)	(%)	(%)	(tr. oz/ton)	(tons)	(pounds)
Newfoundland								
ASARCO Incorporated Buchans Unit, Buchans	1,250 (1,250)	0.22 (0.22)	55.16 (55.30)	3.40 (3.72)	0.69 (0.74)	4.18 (4.44)	35,283 (42,325)	155,245 (183,000)
Newfoundland Zinc Mines Limited Daniel's Harbour	1,500	0.17	62.5	0.04	0.07	0.18	24,988	84,959
New Brunswick								
Brunswick Mining and Smelting Corporation Limited No. 6 and No. 12 Mines, Bathurst	10,000 (10,000)	0.07 (0.12)	51.95 (52.23)	. . (2.69)	. . (0.33)	2.70 (2.77)	354,333 (255,965)	496,066 (614,316)
Heath Steele Mines Limited Newcastle	3,100 (3,100)	0.10 (0.11)	47.99 (48.07)	1.57 (1.86)	0.59 (0.60)	2.70 (2.85)	64,344 (73,229)	128,688 (161,104)
Nigadoo River Mines Limited Robertville	1,000 (1,000)	0.63 (0.62)	44.96 (44.72)	2.84 (1.78)	1.38 (1.26)	6.21 (4.92)	10,559 (8,739)	127,232 (108,363)
Quebec								
Falconbridge Copper Limited Lake Dufault Division, Noranda	1,550 (. .)	0.11 (. .)	52.65 (. .)	. . (. .)	. . (. .)	. . (. .)	29,987 (. .)	65,971 (. .)
Joutel Copper Mines Limited Joutel	700 (700)	0.14 (0.13)	51.25 (51.67)	. . (0.08)	. . (. .)	. . (. .)	8,355 (10,039)	23,394 (26,101)
Manitou-Barvue Mines Limited Val d'Or	1,600 (1,600)	0.21 (0.18)	52.8 (56.3)	. . (. .)	. . (. .)	11.50 (6.21)	5,761 (6,695)	24,196 (24,102)
Mattagami Lake Mines Limited Matagami	3,850 (3,850)	0.13 (0.14)	53.1 (52.7)	. . (. .)	0.48 (0.40)	1.26 (1.18)	162,236 (183,559)	421,814 (513,965)

Table 4. (cont'd)

Company and Location	Mill Capacity	Grade of Zinc Concentrate: Cadmium	Zinc	Lead	Copper	Silver	Zinc Concentrate Produced	Cadmium Content
	(tons ore/ day)	(%)	(%)	(%)	(%)	(tr. oz/ton)	(tons)	(pounds)
Quebec (concl'd)								
Normetal Mines Limited Normetal	1,000 (. .)	0.15 (. .)	52.13 (. .)	. . (. .)	. . (. .)	. . (. .)	7,635 (. .)	22,905 (. .)
Orchan Mines Limited Matagami	1,900 (1,900)	0.11 (0.11)	52.09 (52.38)	. . (0.35)	. . (0.72)	. . (. .)	31,655 (27,155)	69,641 (59,741)
La Société minière Louvem inc. Louvicourt	—	0.03	55.83	. .	. .	3.98	33,963	17,732
Sullivan Mining Group Ltd.								
Cupra Division, Stratford Centre	1,400	0.28	56.58	0.39	1.24	1.54	3,334	18,670
D'estrie Mining Company Ltd. Stratford Centre.	— (1,400)	0.28 (0.28)	56.49 (56.68)	0.39 (0.43)	1.24 (1.20)	1.54 (1.28)	5,521 (13,739)	30,918 (76,938)
Ontario								
Texasgulf Canada Ltd. Timmins	10,000 (10,000)	0.25 (0.27)	51.49 (52.14)	0.39 (. .)	0.45 (0.47)	3.91 (2.30)	504,749 (580,534)	2,530,743 (3,151,000)
Falconbridge Copper Limited Sturgeon Lake Joint Venture	1,200	0.15	52.44	0.59	0.97	3.03	47,206	141,618
Mattabi Mines Limited Sturgeon Lake	3,000 (3,000)	0.14 (0.13)	53.69 (54.43)	. . (. .)	. . (. .)	. . (. .)	127,892 (164,896)	358,098 (428,730)
Noranda Mines Limited Geco Division, Manitouwadge	5,000 (5,000)	0.41 (0.38)	52.84 (53.50)	— (. .)	0.74 (0.67)	1.55 (1.53)	84,141 (132,400)	690,790 (1,006,240)
Selco Mining Corporation Limited South Bay Division, Uchi Lake	500 (500)	0.24 (0.24)	54.46 (54.22)	. . (. .)	0.32 (0.36)	1.49 (1.31)	31,589 (38,318)	151,627 (186,000)
Willroy Mines Limited Manitouwadge	1,400 (1,700)	0.17 (0.18)	52.50 (52.66)	. . (. .)	. . (. .)	5.5 (. .)	20,964 (19,826)	71,278 (72,116)

Table 4 (cont'd)

Company and Location	Mill Capacity	Grade of Zinc Concentrate: Cadmium	Zinc	Lead	Copper	Silver	Zinc Concentrate Produced	Cadmium Content
	(tons ore/ day)	(%)	(%)	(%)	(%)	(tr. oz/ton)	(tons)	(pounds)
Manitoba and Saskatchewan								
Hudson Bay Mining and Smelting	8,500	0.12	48.6	1.0	0.80	1.60	54,696	131,270
Co. Limited	(8,500)	(. .)	(48.6)	(0.9)	(0.70)	(1.34)	(69,550)	(. .)
Flin Flon								
Sherritt Gordon Mines Limited								
Fox Mine, Lynn Lake	2,840	0.115	48.35	. .	1.13	. .	22,492	51,732
	(. .)	(. .)	(. .)	(. .)	(. .)	(. .)	(. .)	(. .)
Ruttan Mine	10,000	0.13	50.12	. .	0.98	. .	97,977	254,740
Ruttan Lake	(. .)	(. .)	(. .)	(. .)	(. .)	(. .)	(. .)	(. .)
British Columbia								
Cominco Ltd.	8,000	0.134	47.66	7.17	. .	2.56	164,006	439,536
Sullivan Mine, Kimberley	(10,000)	(0.13)	(48.24)	(6.12)	(. .)	(2.49)	(114,154)	(296,800)
H.B. Mine, Salmo	1,200	0.42	53.20	2.20	. .	0.70	25,255	212,655
	(. .)	(. .)	(. .)	(. .)	(. .)	(. .)	(. .)	(. .)
Reeves MacDonald Mines	1,000	0.475	51.49	0.95	. .	3.49	1,768	17,470
Limited	(1,000)	(0.50)	(51.98)	(1.82)	(. .)	(3.67)	(12,526)	(125,260)
Annex Mine, Remac								
Kam-Kotia Mines Limited	150	0.41	51.21	1.08	. .	85.32	835	6,841
Silmonac Mine, Sandon	(150)	(0.40)	(51.11)	(. .)	(. .)	(79.00)	(747)	(5,941)
Teck Corporation Limited	110	0.54	38.12	1.63	. .	57.60	263	2,876
Beaverdell Mine, Beaverdell	(110)	(0.41)	(39.90)	(1.65)	(. .)	(58.41)	(287)	(2,353)
Western Mines Limited	1,100	0.23	52.40	0.9	0.6	4.84	34,416	155,144
Lynx and Myra Falls	(1,000)	(0.23)	(51.14)	(. .)	(. .)	(. .)	(37,346)	(174,993)
Buttle Lake,								
Vancouver Island								
Yukon Territory								
Cyprus Anvil Mining Corporation	10,000	a) 0.06	50.80	2.04	. .	1.25	230,494	276,593
Faro Mine, Faro		b) 0.04	29.34	18.37	. .	5.70	77,113	61,690
	(. .)	(. .)	(. .)	(. .)	(. .)	(. .)	(. .)	(. .)

Table 4 (concl'd)

Company and Location	Mill Capacity	Grade of Zinc Concentrate: Cadmium	Zinc	Lead	Copper	Silver	Zinc Concentrate Produced	Cadmium Content
	(tons ore/ day)	(%)	(%)	(%)	(%)	(tr. oz/ton)	(tons)	(pounds)
Yukon Territory (concl'd)								
United Keno Hill Mines Limited	500	0.73	51.53	. .	. .	. .	613	8,935
Husky, Elsa, Dixie, Keno, Townsite Mines, Mayo.	(550)	(0.70)	(53.0)	(. .)	(. .)	(. .)	(527)	(7,330)
Northwest Territories								
Pine Point Mines Limited	10,000	0.10	57.93	1.87	. .	. .	301,447	602,894
Pine Point	(11,000)	(. .)	(56.66)	(1.70)	(. .)	(. .)	(357,457)	(. .)

Source: Mineral Development Sector, Department of Energy, Mines and Resources, Ottawa.
. . Not available

Table 5. Prospective cadmium mine producers

Company and Location	Mill Ore Capacity	Expected Grade of Zinc Concentrate: Cadmium	Zinc	Lead	Copper	Silver	Expected Annual Production of Zinc Concentrate	Cadmium Content	Remarks
	(tons ore/ day)	(%)	(%)	(%)	(%)	(tr. oz/ ton)	(tons)	(pounds)	
Quebec									
Lemoine Mines Limited Chibougamau	—	0.3	53.0	—	0.65	2	16,500	99,000	Start-up early 1976 at the rate of 100,000 tons ore per year.
Northwest Territories									
Nanisivik Mines Ltd. Strathcona Sound	1,500	0.23	60.0	. .	. .	9-10	140,000	644,000	Start-up in late-1976.

Source: Department of Energy, Mines and Resources, Ottawa.
. . Not available

Table 6. Canada, cadmium production, exports and consumption, 1966-75

	Production		Exports	
	All Forms[1]	Refined[2]	Cadmium Metal	Consumption[3]
	(pounds)			
1966	3,236,862	2,217,322	2,012,323	171,000
1967	4,836,317	2,002,892	1,676,676	155,000
1968	5,014,965	2,113,949	1,802,780	125,000
1969	5,213,054	2,123,955	1,686,573	132,136
1970	4,307,953	1,844,706	1,549,035	124,959
1971	4,063,805	1,568,787	1,438,789	117,395
1972	4,267,987	2,251,094	2,289,262[r]	123,395
1973	4,196,594	3,085,219	3,261,521	120,958
1974	2,735,870	2,541,270	1,987,149	105,548
1975[p]	2,682,000	2,518,785	1,406,102	. .

Source: Statistics Canada.
[1]Production of refined cadmium from domestic ores, plus cadmium content of ores and concentrates exported. [2]Refined cadmium from all sources, including that obtained from imported lead and zinc concentrates; includes cadmium in sponge. [3]As reported by consumers.
[p]Preliminary; . . Not available; [r]Revised.

In Canada, the *Northern Miner* publishes the announced sales price for cadmium, but does not publish a monthly average, and on this basis a price range is shown in those months when the price was changed.

Primary cadmium metal producers, including Canadian producers, normally sell metal at individually announced prices. Almost all Canadian metal production is exported to the United States and the European Economic Community (EEC). North American prices, which are quoted on a delivered basis, are best represented by the "U.S. Producer" quotations published by *Metals Week* in New York. European prices, which are quoted on a cif* port-of-discharge basis, with inland freight negotiable and dependent upon market conditions, are best represented by the "Commonwealth (cif)" quotations published by the *Metal Bulletin* in London. Price leadership in the United States is carried out by domestic producers, and Canadian price policy appears to adopt the U.S. basis. In the EEC, the "European Reference Price", cif/ex-works, also quoted by the *Metal Bulletin,* has formed the basis for some metal sales, as it represents the range of prices at which cadmium is sold by European producers as determined by a regular survey conducted by the *Metal Bulletin.* Producer prices are very sensitive to dealer prices and tend to follow them closely despite the fact that it is very difficult to determine the quantity of metal that they represent. The primary dealer quotations are the "N.Y. Dealer" quotations published by Metals Week and the "Sticks, free market" cif quotation published by the *Metal Bulletin.* All prices mentioned above represent cadmium metal having a minimum purity of 99.95 per cent and are set out in the table below which illustrates monthly average during 1975, except for the "N.Y. Dealer" quotations which are the range of weekly averages during the month.

* Cost insurance freight.

Table 7. Cadmium metal prices, 1975

	Northern Miner	Metals Week		Metal Bulletin	
Month	Cominco	U.S. Producer	N.Y. Dealer	Commonwealth	Sticks, free Market
	($ Cdn/lb.)	($ U.S./lb.)		($ U.S./lb.)	
January	4.25	4.250	. .	4.25	2.239-2.328
February	4.25	4.250	2.70-3.00	4.25	2.488-2.594
March	4.25	4.250	2.70-3.00	3.50-4.25	2.550-2.644
April	4.25	4.250	2.50-3.00	3.547	2.365-2.434
May	4.25	4.033	2.55-2.75	3.50	1.971-2.084
June	3.00-4.25	3.385	2.45-2.75	3.50	1.978-2.055
July	3.00	3.000	2.50-2.75	3.50	1.944-2.061
August	3.00	3.000	2.50-2.75	3.50	2.250-2.331
September	2.50-3.00	2.830	2.30-2.65	3.292	2.157-2.203
October	2.50	2.500	2.25-2.45	2.50	1.982-2.030
November	2.50	2.500	2.15-2.35	2.50	1.991-2.041
December	2.00-2.50	2.008	1.75-2.00	2.313	1.754-1.823
Average 1975	3.313-3.50	3.355	2.395-2.677	3.346-3.408	2.139-2.219

Sources: *Northern Miner; Metals Week; Metals Bulletin.*
. . Not available.

Table 8. Western world cadmium metal production, 1974-1975

Country	Cadmium Metal Production[e] 1974 (tons)	1975	Principal Producer, Plant Location, Production where available (in tons)
Austria	29	31	Bleiberger Bergwerks Union A.G., Gailitz
Belgium	1,150	1,052	S.A. Metallurgique d Prayon, Ehein; Societe des Mines & Fonderies de Zinc de la Vielle-Montagne, Balen; Metallurgie Hoboken Overpelt, S.A. Overpelt.
Finland	172	239	Outukumpu Oy: n Kokkola (239).
France	710	422	Societe des Mines & Fonderies de Zinc de la Vieille-Montagne, Viviez; Cie. Royale Asturienne des Mines S.A. Auby; Société Minière et Metallurgique de Penarroya, S.A. Noyelles Godault, (44)
West Germany	1,476	1,121	Dr. L.C. Marquart AG, Beue; "Berzellius" Metallhütten GmbH, Duisburg; Preussag A.G. Metall, Harlingerode; Ruhr-Zink GmbH, Datteln; Duisburger Kupferhutte, Duisburg.
Italy	557	474	AMMI S.P.A., Ponte Nosse, Porto Marghera; Societa Mineraria e Metallurgica di Pertusola SpA Crotone (222).
Netherlands	105	298	Budelco B.V., Budel (298)
Norway	99	50	Det Norsk Zinkkompany A/S, Eitrheim.
Spain	196	198	Cie Royale Asturienne Des Mines, S.A. Arnao; Espanola del Zinc, Carthagena
United Kingdom	309	258	Commonwealth Smelting Ltd., Avonmouth (258)
Yugoslavia	154	154	Hemijska Industrija "Zorka", Sabac; R.M.H.K. Trepca, Kovoska Mitrovica
S.W. Africa	126	105	Tsumeb Corporation Ltd., Tsumeb.
Zaire	300	269	Gecamines, Kolwezi.
Zambia	14	12	Nchanga Consolidated Copper Mines Ltd., Broken Hill Division, Kabwe
India	65	62	Cominco Binani Zinc Ltd., Kerala; Hindustan Zinc Co., Debari
Japan	3,334	2,808	Akita Seiren K.K., Akita; Mitsui Kinzoku Kogyo K.K., Kamioka, Miike, Hikoshima; Mitsubishi Metal Corporation, Akita, Hosokura; Toho Aen K.K., Annaka; Nihon Soda K.K., Aizu; Nihon Kogyo K.K., Mikkaichi; Sumiko I.S.P., Harimo; Hachinohe Seiren K.K., Hachinohe.
Canada	1,376	1,422	Canadian Electrolytic Zinc Limited, Valleyfield (200.5); Cominco Ltd., Trail (682); Hudson Bay Mining & Smelting Co., Limited, Flin Flon (69.8); Texasgulf Canada Ltd, Timmins (470).

Table 8. (concl'd)

Country	Cadmium Metal Production[e]		Principal Producer, Plant Location, Production where available (in tons)
	1974	1975	
	(tons)		
Mexico	384	389	Met-Mek Penoles S.A., Torreon; Zincamex S.A., Saltillo; Industrial Minera Mexico S.A., Nueva Rosita.
Peru	220	200	Centromin Peru, La Oroya.
United States	3,333	2,193	ASARCO Incorporated, Denver, Corpus Christie; Bunker Hill Company, Kellogg; National Zinc Company Inc., Bartlesville; New Jersey Zinc Company, Palmerton; St. Joe Minerals Corporation, Monaca; AMAX Lead & Zinc, Inc., Sauget, (315).
Argentina	33	33	Cia Metalurgica Austral-Argentina S.A., Comodoro Rivadavia; Sulfacid S.A., Borghi.
Australia	794	585	Electrolytic Zinc Company of Australasia Ltd., Risdon; Sulphide Corp. Pty Ltd., Cockle Creek, (167.5); Broken Hill Associated Smelters, Pty Ltd. Port Pirie.
Total	14,936	12,375	

Sources: World Bureau of Metal Statistics; United States Bureau of Mines, Mineral Industry Surveys; [e]Estimates by Mineral Development Sector, Department of Energy Mines and Resources; Published 1975 Shareholder Reports of certain companies.

Outlook

Based upon an average cadmium yield of 6.5 pounds per ton of zinc produced in the western world during the period 1973-1975, cadmium production in 1976 is estimated to be 15,600 tons using a zinc metal forecast of 4,804,000 tons. For consumption to reach this level a 65 per cent increase would be required from the 1975 levels and this seems unlikely. On this basis, prices are expected to remain at depressed levels and continued stockpiling of refined and intermediate cadmium products is anticipated by primary producers. Assuming consumption returns to the 1976 forecast production level in 1977, it is quite possible that the required drawdown of accumulated stocks would preclude balanced supply and demand prior to late-1978-79.

Tariffs

Canada

Item No.		British Preferential	GSP[1]	GATT[2]	General
			(%)	(%)	(%)
32900-1	Cadmium in ores and concentrates	free	free	free	free
31502-1	Cadmium metal, not including alloys in lumps, powders, ingots or blocks	free	free	free	25

Tariffs (concl'd)

United States

USTS no.		GSP	GATT
601.66	Cadmium in ores and concentrates	free	free
632.14	Cadmium metal, unwrought, waste and scrap	free	free
633.00	Cadmium metal, wrought	free	free
632.84	Cadmium alloys, unwrought	free	free

EEC[3]

BTN No.		GSP	GATT
26.01	Cadmium in ore and concentrates	free	free
81.04	Cadmium metal: unwrought, waste and scrap	free	free
	Other	free	4.5

Japan

BTN No.		GSP	GATT
26.01	Cadmium in ores and concentrates	free	free
81.04	Cadmium metal: unwrought, waste and scrap powders, flakes	free	8
	Other	free	12

[1]GSP — Generalized system of Preferences extended to all on most developing countries.
[2]GATT — General Agreement on Tariffs and Trade; [3]EEC — European Economic Community

Calcium

M.J. GAUVIN

Calcium, a member of the alkaline earth family, is silvery white in colour, extremely soft and ductile, and has a low tensile strength. The metal tarnishes rapidly under atmospheric conditions and is a powerful reducing agent. It is the fifth most abundant element in the earth's crust, but does not occur naturally in its elemental form. Although calcium occurs chiefly in limestone, dolomite and sea water, high-calcium limestone deposits are the principal sources of calcium metal.

Metallic calcium may be recovered by electrolytic or thermal methods. Extraction was previously carried out by the fused salt electrolysis of calcium chloride, but today it is done only by aluminothermic reduction of lime by a non-continuous process. There are only three producers of metallic calcium in the noncommunist world: Chromasco Limited in Canada; Planet-Wattohm S.A., a subsidiary of Compagnie de Mokta, in France; and Charles Pfizer and Co. Inc. at Canaan, Conn., in the United States. All three use a thermal reduction method. Canada continued to be a leading international producer and supplier of calcium metal in 1975. Production and consumption of calcium amount to approximately 1,000 tons a year in the noncommunist world. Calcium metal is also produced in the U.S.S.R., which exports small quantities to Western Europe and the United States.

Canadian industry

Chromasco Limited produces calcium metal at its metallurgical plant at Haley, near Renfrew, Ontario. It utilizes the same vacuum retort method, known as the "Pidgeon process," used to produce its principal product, magnesium. Other products from the Haley operation, in addition to magnesium and calcium metals, include magnesium and calcium alloys and barium, strontium and thorium metals. To make calcium, high-purity quicklime (CaO) and commercially pure aluminum are briquetted and then charged into horizontal electric retorts made of chrome-nickel steel. Under vacuum and at a temperature of about 1170°C, the aluminum reduces the quicklime to form a calcium

Table 1. Canada, calcium production and exports, 1974-75

	1974		1975[e]	
	(pounds)	($)	(pounds)	($)
Production (metal)[1]	1,049,587	915,487	826,000	1,108,000
Exports (metal)				
United States	550,700	465,000	579,000	559,000
Mexico	121,100	99,000	76,200	63,000
West Germany	61,700	64,000	16,100	24,000
United Kingdom	10,000	19,000	11,600	24,000
Other countries	4,000	4,000	—	—
Total	747,500	651,000	682,900	670,000

Source: Statistics Canada.
[1]Shipments of calcium metal, and calcium metal used in production of calcium alloys.
[p]Preliminary; — Nil.

vapour. This calcium vapour crystallizes at about 680°-740°C in the water-cooled condenser section of the retort, which projects outside the furnace wall. The initial product, known as "crowns," grades about 98 per cent calcium. Higher purities are obtained by subsequent refining operations.

Chromasco makes four main grades of calcium: Grade 1, chemical standard, 99.7 per cent calcium with up to 0.2 per cent magnesium and minor amounts of other elements; Grade 2, nuclear quality, 99.4 per cent calcium with magnesium up to a maximum of 0.5 per cent; Grade 3, battery grade, 98.5 per cent calcium with a maximum of 0.5 per cent magnesium, 0.15 per cent nitrogen maximum and 0.45 per cent aluminum maximum; Grade 4, commercial crowns, 98.0 per cent calcium, 0.5 to 1.5 per cent magnesium, 0.15 per cent nitrogen maximum, 0.45 per cent aluminum maximum.

Canadian production of calcium in 1975 was 826,000 pounds, down from the record 1,049,587 pounds produced in 1974. Most of our production is exported, 682,900 pounds being sold in foreign markets in 1975, compared with 747,500 pounds in 1974. Exports to the United States totalled 579,000 pounds in 1975 compared with 550,700 pounds in 1974.

Uses

Metallic calcium is a powerful reducing agent. Accordingly, one of its major applications is in metallurgical processes for removing oxygen and halogens from various metals which resist reduction by normal reductants such as carbon, hydrogen and natural gas. Among such metals are columbium, tantalum, titanium, thorium, uranium, vanadium and zirconium. As a purifier, calcium removes residual sulphur, phosphorus and oxygen from steel. The major usage of calcium is to remove bismuth, antimony and arsenic from lead. Metallic calcium is also used in producing organocalcium compounds for special lubricants, corrosion inhibitors and detergents, and to form alloys with magnesium, aluminum, lead, lithium and silicon. In certain types of storage batteries, a lead alloy containing only 0.1 per cent calcium exhibits properties superior to an alloy containing the 3 per cent antimony generally used. These new storage batteries do not require the addition of any water. Alloys of calcium and silicon, and of calcium, silicon and magnesium are widely used in the steel industry to control grain size, inhibit carbide formation, improve ductility and reduce internal flaws.

Table 2. Canada, calcium production and exports, 1966-75

	Production[1]	Exports
	(pounds)	
1966	249,179	242,800
1967	543,692	513,000
1968	468,511	353,700
1969	942,682	724,600
1970	443,557	174,100
1971	355,247	152,900
1972	469,378	253,100
1973	651,921	378,300
1974	1,049,587	747,500
1975[p]	826,000	682,900

Source: Statistics Canada.
[1]Producers' shipments of calcium metal, and calcium metal used in production of calcium alloys.
[p]Preliminary.

Outlook

A shortage of raw materials is almost impossible to perceive, since limestone and other calcium minerals are readily available and inexpensive. Consumption of calcium metal is limited and, unless its use is greatly accelerated, existing producers will be able to supply the market adequately in the foreseeable future. The longer-term outlook for the metal could improve somewhat if the growth rate for one of the metal's major uses; in hydraulic cements, should increase. The growth rate in calcium consumption should also rise as the usage of "maintenance-free" automotive batteries continues to grow. These permanently (hermetically) sealed batteries use calcium-lead alloy instead of antimonial-lead alloy in the battery grids and require virtually no maintenance during normal battery life.

Prices

The price of calcium metal crowns increased in March 1975 from $1.24 to $1.33 a pound. This price was maintained for the remainder of the year. The price of calcium silicon alloy was 57 cents a pound throughout the year. According to *Metals Week*, December 29, 1975, United States prices were as follows:

	(¢ per lb.)
Calcium metal, ton lots, full crowns	133
Calcium alloy, fob shipping point, freight equalized to nearest main producer, carload lots:	
calcium silicon, 32% calcium	57

Tariffs

Canada

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
		(% ad. val.)			
92805-1	Calcium metal	10	15	25	10

United States

Item No.		On and after January 1 1971	1972
		(% ad. val.)	
632.16	Calcium metal, unwrought	9	7.5
633.00	Calcium metal, wrought	10.5	9

Sources: For Canada, The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa. For United States, Tariff Schedules of the United States Annotated (1976) T.C. Publication 749.

Cement

D.H. STONEHOUSE

Portland cement is produced by burning, usually in a rotary kiln, an accurately proportioned, finely ground mixture of limestone, silica, alumina and iron oxide. Kiln discharge, in the shape of rough spheres, is a fused, chemically complex mixture of calcium silicates and aluminates, termed clinker, which is mixed with gypsum, 4 to 5 per cent by weight, and ground to a fine powder to form portland cement. By close control of the raw mix, of the burning conditions and of the use of additives in the clinker grinding procedure, finished cements displaying various desirable properties can be produced.

The three basic types of portland cement are produced by most Canadian cement manufacturers — Normal Portland, High-Early-Strength Portland and Sulphate-Resisting Portland. Moderate Portland Cement and Low Heat of Hydration Portland Cement, designed for use in concrete to be poured in large masses such as in dam construction, are manufactured by several companies in Canada. Masonry cement (generic name) includes such proprietary names as Mortar Cement, Mortar Mix (unsanded), Mason's Cement, Brick Cement and Masonry Cement. The latter, produced by portland cement manufacturers, is a mixture of portland cement, finely ground high-calcium limestone (35 to 65 per cent by weight) and a plasticizer. The other products do not necessarily consist of portland cement and limestone, and may include a mixture of portland cement and hydrated lime and/or other plasticizers.

Cement has little use alone but, when combined with water, sand, gravel, crushed stone or other aggregates in proper proportions, acts as a binder, cementing the materials together as concrete. Concrete has become a widely used and readily adaptable building material which can be poured on site in large engineering construction projects or used in the form of delicate precast panels or heavy, prestressed columns and beams in building construction.

Specifications

Portland cement used in Canada should conform to the specifications of CSA Standard A5 — 1971 published by the Canadian Standards Association. This standard covers the five main types of portland cement as follows: Normal, Moderate, High-Early-Strength, Low Heat of Hydration, and Sulphate-Resisting Portland cements. Masonry cement produced in Canada should conform to the CSA Standard A8 — 1970.

The cement types manufactured in Canada that are not covered by the CSA standards generally meet the appropriate specifications of the American Society of Testing and Materials (ASTM).

Cembureau, The European Cement Association, has published *Cement Standards of the World — Portland Cement and its Derivatives,* in which standards are compared. Cembureau's *World Cement Directory* lists production capacities by company and by country.

Summary

Cement is one of a number of industrial mineral commodities produced in Canada in direct support of the construction industry. Others are clays, lime, sand and gravel, stone, asbestos and gypsum. The construction industry is the largest single employer in Canada and one that is immediately affected by changes in the country's economic climate.

In Canada construction is categorized broadly as building construction and engineering construction, and the values of each type give some basis for comparison. Historically, building construction has represented about 60 per cent of the total value of construction and one element within this general category — residential construction — has normally accounted for 30 per cent of total value, or one-half of building construction. In current dollars, construction is credited with about 17 per cent of gross national expenditure. In 1975 capital and repair expenditure on construction was $28.1 billion (preliminary actual), up 13.8 per cent over the 1974 figure of $24.7 billion (actual). Forecasts indicate a 1976 investment of $31.5 billion, 12 per cent more than in 1975. Housing starts in 1975, at 231,456, exceeded the government-set goal of 210,000 and surpassed the 1974 total of 222,123. Expenditures on housing are expected to increase by 20 per cent in 1976. Problems associated with the supply of material and labour proved to be less disruptive than anticipated. The principal deterrent to construction activity in 1975 was the high degree of uncertainty related to the general economic climate which produced cautious commitment by major business concerns. This atmosphere carried into 1976 as the performance of the Anti Inflation Board, constituted late in 1975, was viewed with some apprehension. Residential price indexes rose 6.9 per cent in 1975, including a 3.4 per cent increase for materials and a 13.2 per cent increase for labour. A 9.4 per cent increase in the non-residential sector was made up of increases of 5.3 per cent for materials and 14.1 per cent for labour.

In its supply role to a volatile industry, the cement industry, in turn, must be capable of adjusting and remaining competitive. Markets and raw material adequacy generally have influenced the selection of new cement plant sites. However, environmental considerations, labour situations and energy sources are becoming increasingly important factors in planning industry expansion and in keeping some plants operative. Mar-

Table 1. Canada, cement production and trade, 1974-75

	1974		1975p	
	(short tons)	($)	(short tons)	($)
Production[1]				
By province				
Ontario	4,606,332	103,579,695	4,021,000	92,491,000
Quebec	3,248,386	83,518,259	3,489,000	90,715,000
British Columbia	981,472	27,087,966	1,026,000	28,731,000
Alberta	1,052,336	26,779,957	977,000	25,410,000
Manitoba	702,012	13,795,155	523,000	10,468,000
Saskatchewan	266,232	6,900,756	240,000	6,249,000
New Brunswick	. .	4,587,147	. .	4,403,000
Newfoundland	. .	4,024,604	. .	3,468,000
Nova Scotia	. .	4,375,012	. .	3,348,000
Total	11,436,398	274,648,551	10,763,000	265,283,000
By type				
Portland	11,024,688	. .	10,375,532	. .
Masonry[2]	411,710	. .	387,468	. .
Total	11,436,398	274,648,551	10,763,000	265,283,000
Exports				
Portland cement				
United States	1,264,446	23,573,000	1,082,010	23,229,000
Other countries	1,440	69,000	16,530	673,000
Total	1,265,886	23,642,000	1,098,540	23,902,000
Cement and concrete basic products				
United States	. .	15,471,000	. .	11,580,000
Other countries	. .	191,000	. .	410,000
Total	. .	15,662,000	. .	11,990,000
Imports				
Portland cement, white				
United States	26,463	1,215,000	25,895	1,310,000
Japan	434	18,000	274	14,000
Belgium-Luxembourg	—	—	60	5,000
Total	26,897	1,233,000	26,229	1,329,000

Table 1. (concl'd)

	1974		1975p	
	(short tons)	($)	(short tons)	($)
Cement, nes[3]				
United States	249,297	7,254,000	437,167	16,671,000
United Kingdom	607	23,000	523	68,000
France	64	6,000	203	58,000
West Germany	146	49,000	17	8,000
Total	250,114	7,332,000	437,910	16,805,000
Total cement imports	277,011	8,565,000	464,139	18,134,000
Refractory cement and mortars				
United States	. .	3,713,000	. .	5,283,000
Ireland	. .	195,000	. .	299,000
United Kingdom	. .	305,000	. .	159,000
Denmark	. .	25,000	. .	29,000
France	. .	5,000	. .	17,000
Other countries	. .	110,000	. .	35,000
Total	. .	4,353,000	. .	5,822,000
Cement and concrete basic products, nes				
United States	. .	1,302,000	. .	1,991,000
Italy	—	—	. .	36,000
West Germany	. .	39,000	. .	25,000
United Kingdom	. .	27,000	. .	7,000
Mexico	. .	5,000	. .	2,000
Japan	. .	2,000	—	—
France	. .	2,000	—	—
Total	..	1,377,000	. .	2,061,000
Cement clinker				
United States	12,284	296,000	8,351	208,000

Source: Statistics Canada.
[1]Producers' shipments, plus quantities used by producers. [2]Includes small amounts of other cements. [3]Includes grey portland, masonry, acid proof, aluminous and other specialty types of cement.
pPreliminary; nes Not elsewhere specified; . . Not available; — Nil.

kets for cement tend to be regional because transportation costs represent much of the laid-down price to the consumer and only rarely, as in the case of special cements or in periods of regional shortage, are shipments made beyond normal distribution boundaries. Production, therefore, is determined by the regional construction activity and by interpretation of construction intentions.

An export market for cement developed in the northeastern and southeastern United States during the early 1970's because of a production deficiency in those regions. Canadian production became influenced, at least regionally, by construction activity and intentions in that country. The lack of production capability was brought on by plant closures forced by the application of environmental legislation, and by the lack of appeal the industry has had to attract capital investment for either the erection of new plants or the modernization of existing plants. During 1974 and 1975 a depressed construction industry in the United States gave temporary and partial relief from the cement shortage situation which has seen imported cement accepted from as far away as Norway.

At least three contracts to supply major amounts of cement clinker to U.S. cement companies from Canadian plants exist. Whether this will become a trend in the face of high fuel costs and pollution regulations remains to be seen. It is unlikely, however, that any new or expanded capacity in the United States through the next two or three years will do any more than meet demand.

Cement production capacity in Canada at the end of 1975, was about 16.6 million tons a year, excluding the capacity of three plants which only grind clinker, and including some listed capacity which could be reactivated or maintained only at considerable expense. Capacity increases during 1975 totalled 1,575,000 tons a year: a second kiln at the St. Constant, Quebec plant of Canada Cement Lafarge Ltd. (525,000 tons), completion of an expansion program by Lake Ontario Cement Limited at Picton, Ontario (850,000 tons) and addition of a new 500,000 tpy kiln at Canada Cement Lafarge's Exshaw, Alberta plant (net increase of 200, 000 tons, actually operative in early 1976). Previously listed capacities were adjusted to more realistic values so that the net capacity increase, 1975 over 1974, is only 727,000 tons a year. Theoretical capacity utilization in 1975 was only 65 per cent.

A typical feature of the cement manufacturing industry is its diversification and vertical integration into related construction materials industries. Many cement companies also supply ready-mix concrete, stone aggregates, and preformed concrete products such as slabs, bricks and prestressed concrete units.

Canadian industry and developments

Atlantic region. There are three cement-manufacturing plants in the Atlantic provinces serving the markets in the immediate area by road, rail and water transportation routes. The plants represent 4.7 per cent of Canadian cement production capacity in a region having 9.5 per cent of the total population of Canada.

A plant located at Corner Brook, Newfoundland, established in 1951, is operated by North Star Cement Limited. Limestone and shale, raw materials for the dry process being used, are quarried in the immediate area, and gypsum is purchased from Flintkote Holdings Limited, which quarries gypsum at Flat Bay, about 60 miles south of Corner Brook. Shipments of portland cement are made by rail and by sea, mostly to provincial markets. Production depends directly on construction activity.

During 1974 Lehigh Portland Cement Company, Allentown, Pennsylvania, in joint agreement with British Newfoundland Exploration Limited (Brinex), assessed the raw materials available in the Port au Port district of Newfoundland with the objective of establishing a 1-million-ton-a-year portland cement facility in the region. Obviously, a buoyant export market for portland cement or for clinker would be needed in order to support a plant of such capacity. Early in 1975 Lehigh terminated its association with the project while Brinex continued to investigate the feasibility of an industrial mineral complex based on high calcium limestone.

Nova Scotia's only cement manufacturing facility, a single-kiln, dry-process plant incorporating the most modern analytical and control devices, was established in 1965 by Canada Cement Company, Limited (now Canada Cement Lafarge Ltd.) at Brookfield. Limestone at the plant site is chemically very close to a natural cement rock; but variations in lime, alumina and iron content necessitate the addition of iron oxide, coal ash and high-calcium limestone, all of which are available nearby. Gypsum is purchased from the Milford quarry of National Gypsum (Canada) Ltd., about 25 miles south of Brookfield. Portland cement is marketed in bulk or package under the brand name "Maritime" cement. In 1975 production of portland cement in Nova Scotia decreased by about 28 per cent from the previous year. During the second half of the year work began on a $25 million expansion program which will double the present plant capacity by 1978 with the installation of a second kiln.

Canada Cement Lafarge Ltd. also operates a cement-manufacturing plant at Havelock, New Brunswick. This plant, built in 1951 and expanded in 1966 by the addition of a second kiln, now has a capacity of 450,000 tons a year. The company increased plant capacity with the addition of heavier grinding equipment and larger storage facilities. Shipments in 1975 were down about 16 per cent from 1974.

Table 2. Canada, cement production, trade and comsumption, 1966-75p

	Production[1]	Exports[2]	Imports[2]	Apparent Consumption[3]
	(short tons)			
1966	8,930,552	407,395	50,615	8,573,772
1967	7,994,954	328,018	44,118	7,711,054
1968	8,165,805	366,506	51,500	7,850,799
1969	8,250,032	634,208	53,396	7,669,220
1970	7,945,915	566,521	97,191	7,476,585
1971	9,075,915	887,846	55,874	8,243,943
1972	10,038,617	1,299,329	43,372	8,782,660
1973	11,125,738	1,409,588	128,656	9,844,806
1974	11,436,398	1,265,886	277,011	10,447,523
1975p	10,763,000	1,098,540	464,139	10,128,599

Source: Statistics Canada.
[1]Producers' shipments plus quantities used by producers. [2]Does not include cement clinker. [3]Production plus imports less exports.
pPreliminary.

Quebec. In the Province of Quebec, five companies operate a total of seven cement manufacturing plants. Regionally, the companies producing cement in Quebec compete for the construction markets in the Montreal and Quebec City areas as well as for markets in more remote regions where major heavy construction projects are under way — the James Bay project, the Manicouagan project, and the iron ore development north of Port-Cartier. Preparations for the 1976 Olympics added to construction activity in Montreal, and construction of the Ste-Scholastique airport project continued through 1975. Major export markets in the United States, developed over the past few years for both cement and cement clinker, accepted less product in 1975 as the expected recovery of the construction industry in that country was not evident until early 1976. Cement production in Quebec decreased slightly in 1974.

The Montreal East plant of Canada Cement Lafarge Ltd. at Pointe-aux-Trembles has been operated as part of the Canada Cement complex since it was acquired in 1909. Material from the adjacent quarry approximates a natural raw mix which requires only minor amounts of sand, iron oxide and high-calcium limestone for corrective purposes. Situated a mile from docking facilities on the St. Lawrence River, the plant has access to water transportation. The Montreal plant will undergo major rehabilitation commencing in 1976. Plans to replace seven old, wet process kilns with two dry process, preheater equipped kilns will result in an effective total capacity at completion of the project of 500,000 tons a year. Present capacity has been adjusted downward to 1,000,000 tons a year.

Canada Cement Lafarge's plant at St. Constant, south of Montreal, was to have increased capacity by 500,000 tons a year during 1974. Construction difficulties delayed completion of the additional kiln and ancillary equipment until early 1975. The plant is modern, technically efficient, and could conceivably replace some of the capacity of Canada Cement Lafarge's older Montreal East plant. The company's Hull operation, on the site where cement was first produced in Canada, was closed as a producing facility at the end of 1975. The plant has not been dismantled and is currently serving as a distribution terminal.

Miron Company Ltd. operates a dry-process plant at St-Michel. The company also supplies concrete and other building materials to the construction industry and maintains a contracting division. During 1973, Genstar Limited of Montreal acquired the majority of Miron shares. Genstar through its cement division, operates Inland Cement Industries Limited in Winnipeg, Regina and Edmonton, and Ocean Cement Limited in Bamberton, B.C.

St. Lawrence Cement Company has a plant at Villeneuve, near Quebec City, capable of manufacturing about 790,000 tons of cement a year. Limestone and shale are available at the site, iron oxide and gypsum are brought in. Finished products include normal portland cement, medium-heat-of-hydration cement and masonry cement. Shipments are made in bulk or in bags by truck, rail, and ship.

Independent Cement Inc. began construction of its cement-manufacturing plant at Joliette, Quebec in 1965, and it went on stream in the fall of 1966 with a two-kiln operation capable of producing about 435,000 tons a year. A third kiln, adding about 220,000 tons a year to plant capacity, started up in 1970. In 1972, a fourth kiln of similar design was installed. This company has pursued an aggressive sales campaign and has captured a major share of the Montreal area markets. Early in 1976 negotiations between Independent and St. Lawrence were underway for a St. Lawrence take over.

Ciment Quebec Inc. was established in 1952 at St-Basile, 40 miles west of Quebec City, as a single-kiln operation. Two additional kilns were installed to boost production capacity to about 380,000 tons a year.

Ontario. Four companies operate a total of six cement-manufacturing plants in the Ontario region, serving industrial and urban growth areas in southern Ontario, and shipping to points in Quebec and northern Ontario as well as the United States. One other company operates a clinker grinding plant.

The industrialized and population-intense region surrounding Lake Ontario and Lake Erie continues to grow and, in so doing, provides markets for cement in many engineering, commercial, industrial and residential building projects, all of which have shown continued growth. The Ontario cement producers represent 39.5 per cent of total production capacity in a region occupied by about 36 per cent of the total Canadian population. Steady growth is indicated by continued investment in additional capacity.

Lake Ontario Cement Limited is one of Canada's largest cement exporters. The plant is located at Picton, where favourable raw materials are situated adjacent to deep water, permitting comparatively inexpensive bulk shipments to Great Lakes and St. Lawrence Seaway ports. Shipments, also made by truck and by rail to domestic markets, continued at an all-time high in 1975. The company's plant expansion program was furthered in 1975 with the addition of a new preheater kiln which doubled the plant capacity. In early 1976 Lake Ontario made the first shipment of 18,000 tons of clinker to Martin Marietta Corporation at Bay City, Michigan as part of a $20 million three-year supply contract.

The Belleville plant of Canada Cement Lafarge Ltd., one of the original operations grouped to form the Canada Cement Company in 1909, was phased out of operation at the end of October, 1973, subsequent to the company's new 1.1-million-ton-a-year plant at Bath commencing start-up procedures in mid-September. Production at the Bath plant has increased progressively during 1974 and 1975.

Canada Cement Lafarge operates a plant at Woodstock, Ontario capable of producing about 600,000 tons a year from a two-kiln, wet process. The plant was constructed in 1956 to serve the developing area of southwestern Ontario. Clay overburden from the limestone quarry is of a quality that can be utilized in manufacturing masonry cement, high-early-strength cement and normal portland cement.

St. Lawrence Cement Company built its Clarkson, Ontario plant in 1957 and, with the expansion to 1.75 million tons a year in 1968, it became Canada's largest producing plant. The plant now combines a wet and dry process.

Limestone for the plant is brought by boat from Ogden Point, 100 miles east of Toronto on the north shore of Lake Ontario. A mile-long, overhead, covered conveyor is used to transport stone from the lake carriers to the plant. Gypsum is trucked from producers in southwestern Ontario. The market area for finished cement product is mainly the Toronto-Hamilton strip and southern Ontario served by rail and truck deliveries. Large quantities of clinker are exported to United States points. The company sold its assets in Wyandotte Chemical Corporation, Michigan in compliance with the U.S. Federal Trade Commission divesture order issued in early 1973.

St. Marys Cement Limited operates two plants in Ontario. The original plant at St. Marys was constructed in 1912 to serve the Toronto area. It has been expanded and modernized over the years and with the installation of a sixth kiln by 1976 will have the capacity to produce over 1.4 million tons a year. A new and highly automated plant, built at Bowmanville during 1967 and 1968, was expanded during 1973 with the addition of a second kiln to increase capacity to ship product via truck and rail to the major marketing area of metropolitan Toronto.

Medusa Products Company of Canada, Limited, Paris, Ontario grinds a white clinker imported from the Medusa plant at York, Pennsylvania. The white cement is sold mainly in Ontario.

Prairie region. Two companies, Canada Cement Lafarge Ltd. and Inland Cement Industries Limited, operate a total of five clinker-producing plants in the Prairie region along with two clinker-grinding plants. The region accounts for 15.6 per cent of Canadian cement-producing capacity exclusive of the grinding plants and during 1975 produced about 67 per cent of that capacity.

Canada Cement Lafarge Ltd. operates a cement manufacturing plant at Fort Whyte, near Winnipeg, Manitoba. The original facility has been enlarged and rebuilt several times and is today a highly efficient plant capable of producing 630,000 tons of cement a year. High-calcium limestone is obtained from the company's quarry at Steep Rock on the shore of Lake Manitoba, silica from Beausejour and clay from Fort Whyte. Products include portland cement, sulphate-resisting cement, oil-well cement and masonry cement for a market area extending from the United States border to the most northerly populated areas, and eastward halfway across northern Ontario.

At Exshaw, Alberta, a cement plant has been operated by the Canada Cement group since 1910. A modernization and expansion program begun three years ago continued during 1975 with the installation of a new 500,000-ton-a-year kiln. The program included the development of a new quarry and the relocation of several roads and structures in Exshaw. Production capacity will be 800,000 tons a year by 1976. Finished cement is shipped by rail and truck mainly to consumers in Alberta and western Saskatchewan. Large quantities of clinker are shipped to the company's grinding, storage and distributing plant at Edmonton, Alberta. A facility at Floral, near Saskatoon, Saskatchewan was built in 1964 as a distribution terminal and in 1966 was expanded to include clinker-grinding equipment. When the demand for cement warrants, the Floral establishment can be expanded further to become a fully integrated cement manufacturing and distributing plant.

Inland Cement Industries Limited, a Genstar Limited subsidiary, operates three cement-manufacturing plants, one in Winnipeg, Manitoba, one in Regina, Saskatchewan and one in Edmonton, Alberta. The Winnipeg plant came on stream in 1965 to increase the company's total production capacity to over one million tons a year. A limestone quarry at Mafeking, Manitoba, near the Manitoba — Saskatchewan border, supplies limestone to the Regina plant, while the Winnipeg plant is supplied from Steep Rock. The Edmonton plant is supplied from Cadomin, Alberta, by a 5,000-ton unit train which provides an automated materials-handling system. Other raw materials are obtained close to the plant sites. A market area stretching east to the Lakehead and west to, and including, British Columbia is served by Inland's facilities.

Houg Cement, Limited, Edmonton was scheduled to produce cement from marl early in 1974 near Clyde, some 40 miles northeast of Edmonton. Details are limited, but a $5 million expenditure for a 60,000 ton-a-year plant has been reported. Local markets would consist principally of ready-mix operations.

Pacific region. Construction activity in British Columbia has been maintained at a high level despite labour difficulties and escalating costs. The outlook towards increased activity in construction was reflected in Genstar's decision to build a 750,000-ton-a-year plant in the Vancouver area and amplified by their decision to increase the size of this plant to 1.1 million tons even before construction had begun. The new plant will be located on Tilbury Island and will cost an estimated $90 million. Inland Cement Industries Limited and Ocean Cement & Supplies Ltd. are operated as a cement division of Genstar. Ocean Cement & Supplies Ltd. quarries limestone at Bamberton on Vancouver Island for cement manufacture and for use as an aggregate. The cement plant, with a capacity of about 700,000 tons a year, will be phased out upon completion of the new facility on the mainland.

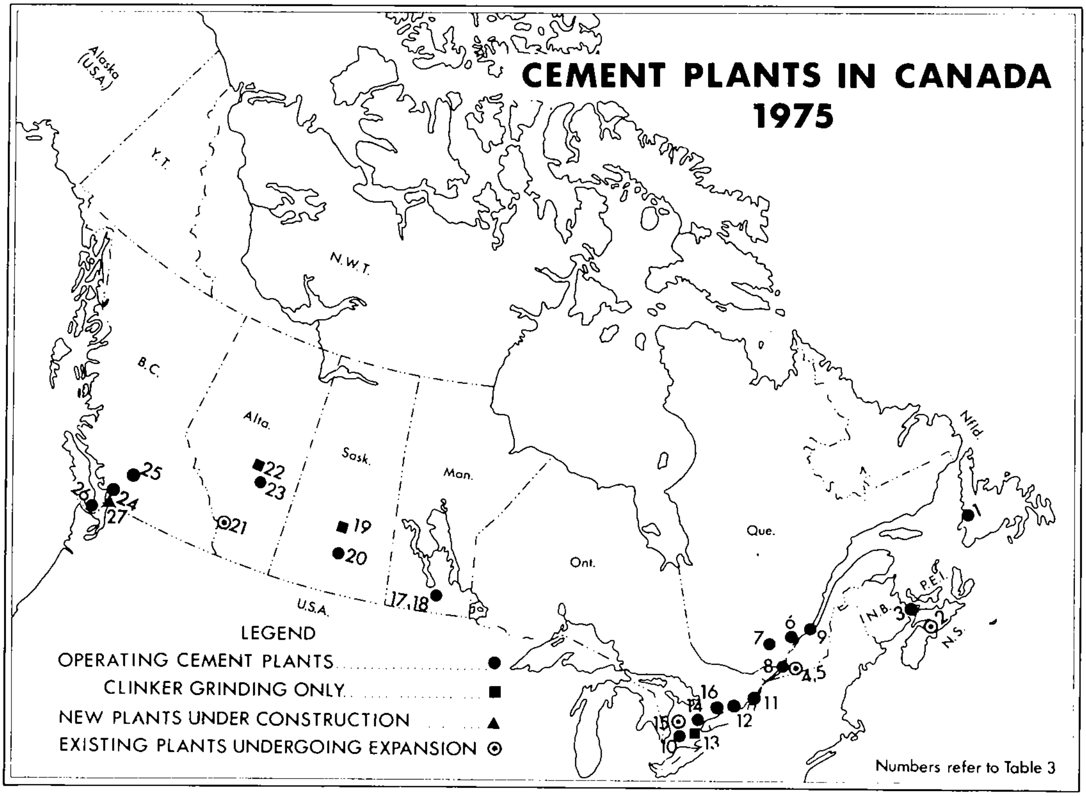
Table 3. Cement plants – approximate annual capacities, end of 1975

Company	Plant Location	Process	Capacity
Atlantic region			
1. North Star Cement Limited	Corner Brook, Nfld.	dry	175,000
2. Canada Cement Lafarge Ltd.	Brookfield, N.S.	dry	260,000[1]
3. Canada Cement Lafarge Ltd.	Havelock, N.B.	dry	360,000
Total Atlantic region			795,000
Quebec			
4. Canada Cement Lafarge Ltd.	Montreal	wet	1,000,000[2]
5. Canada Cement Lafarge Ltd.	St-Constant	dry	1,050,000[3]
6. Ciment Quebec Inc.	St-Basile	wet	380,000
7. Independent Cement Inc.	Joliette	dry	875,000
8. Miron Company Ltd.	St-Michel	dry	1,050,000
9. St. Lawrence Cement Company	Villeneuve	wet	787,000
Total Quebec region			5,142,000
Ontario			
10. Canada Cement Lafarge Ltd.	Woodstock	wet	595,000
11. Canada Cement Lafarge Ltd.	Bath	dry	1,100,000
12. Lake Ontario Cement Limited	Picton	dry	1,670,000[4]
13. Medusa Products Company of Canada, Limited	Paris	grinding only	
14. St. Lawrence Cement Company	Clarkson	wet/dry	1,750,000
15. St. Marys Cement Limited	St. Marys	wet	743,000[5]
16. St. Marys Cement Limited	Bowmanville	wet	700,000
Total Ontario region			6,558,000
Manitoba			
17. Canada Cement Lafarge Ltd.	Fort Whyte	wet	630,000
18. Inland Cement Industries Limited	Winnipeg	wet	350,000
Saskatchewan			
19. Canada Cement Lafarge Ltd.	Floral	grinding only	
20. Inland Cement Industries Limited	Regina	dry	227,500
Alberta			
21. Canada Cement Lafarge Ltd.	Exshaw	wet	800,000[4]
22. Canada Cement Lafarge Ltd.	Edmonton	grinding only	
23. Inland Cement Industries Limited	Edmonton	wet	577,500
Total Prairie region			2,585,000

Table 3. (concl'd)

Company	Plant Location	Process	Capacity
British Columbia			
24. Canada Cement Lafarge Ltd.	Lulu Island	wet	615,000
25. Canada Cement Lafarge Ltd.	Kamloops	dry	210,000
26. Ocean Construction Supplies Limited	Bamberton	wet	700,000
27. Ocean Construction Supplies Limited	Tilbury Island	dry	1,100,000[6]
Total British Columbia region			1,525,000
Total capacity			16,605,000

Source: Published data and company communication.
[1]Capacity to be doubled. [2]Undergoing rehabilitation, scheduled for completion 1976. [3]Capacity increase scheduled for 1974 was delayed to 1975. [4]Capacity was increased in 1975. [5]Capacity increase scheduled for 1976. [6]Not included in totals, under construction.



Canada Cement Lafarge Ltd. produces cement at Richmond on Lulu Island near Vancouver, British Columbia, using limestone barged down the Strait of Georgia from a quarry at Vananda on Texada Island. The plant was built in 1958, and later the capacity was doubled to the present 615,000 tons a year. A new plant with a capacity of over 210,000 tons a year began production in 1970 at Kamloops, British Columbia.

Table 4. Canada, cement plants, kilns, production and capacity, 1971-75

	Plants	Kilns	Approximate Annual Capacity	Production[1]	Capacity Utilization
			(tons)	(tons)	%
1971	24	58	14,729,000	9,326,312	63
1972	24	59	14,948,000	9,962,455	67
1973	24	58	15,728,000	10,884,000	69
1974	24	58	15,878,000	11,308,000	71
1975	24	58	16,605,000	10,763,000	65

Source: Statistics Canada and Company data.
[1]Production is preliminary in each case.

Table 5. Canada, destination of domestic cement shipments[1], 1975

	(short tons)
Ontario	3,611,447
Quebec	2,855,260
Rest of Canada	3,336,868
Canada total	9,803,575
Exports	750,094
Total shipments	10,553,669

Source: Statistics Canada.
[1]Special compilation. Direct sales from producing plants.

Markets and trade

Cement markets are regional in scope and are centred in developing urban areas where construction activity is concentrated, or in areas where mining or heavy engineering construction projects are being performed. The normal market area of a given cement-producing plant depends on the amount of transportation cost that the selling price can absorb. A potential large volume of sales could warrant a secondary distribution terminal; water transportation to a distribution system could extend a plant's market area even farther. Because raw materials for cement manufacture are available in nearly all areas, most countries can supply their own cement requirements if the market volume warrants a plant. Few countries rely entirely on imports for their cement needs. However, some countries rely heavily on export markets for their cement production in order to operate facilities economically.

Specialty cements, such as white cement, are transported greater distances than ordinary grey portland cement, when the transportation costs do not represent as high a proportion of the landed price and when quantities required are generally much smaller than for portland cement. Cement shortages in countries experiencing a buoyant surge in construction have led to exceptions to the norm and resulted in cement being shipped unusual distances, e.g. Norway shipped cement to United States during 1973 and Saudi Arabia was seeking 1 million tons from Canada during 1974.

Cement from plants in the United States and Canada is traded between the two countries where competition and tariffs permit. The 1973 situation in which record amounts of both cement and clinker were exported to the United States market was an anomaly created by the combined effects of a cement shortage in parts of the United States and an extremely buoyant construction industry. A sliding economy had an immediate and strong effect on United States construction activity during 1974 and the cement industry in turn was forced to adjust to reduced demand for its product. Exports of portland cement from Canada to the United States were reduced by about 10 per cent in 1974, and a further 14 per cent in 1975 as the predicted recovery in construction activity did not materialize. Canadian market areas are reflected in the distribution of shipments from Canadian producers, see Table 5. A depressed cement market in Canada followed that in the United States, with a most pronounced drop in production and shipments noted in early 1975. Recovery, however, seemed more rapid in Canada and a trend to greater cement usage began in late-1975.

Although cement is used mainly in the construction industry, significant amounts are used also in the mining industry to consolidate backfill. Amounts so used grew from about 5,000 tons in 1960 to a reported 231,000 tons in 1970, the increase being related to the mechanization of backfilling techniques and to research conducted with support from the National Research Council's Industrial Research Assistance Program. In 1975 the amount so used was recorded as 202,717 tons in 15 operations.

Table 6. Canada, mineral raw materials[1] used by the cement industry

Commodity	1973	1974[p]
	(short tons)	
Shale	588,114	531,709
Limestone	15,868,345	15,925,962
Gypsum	503,204	562,043
Sand	196,042	296,678
Clay	1,058,537	952,737
Iron oxide	114,996	102,769

Source: Statistics Canada.
[1]Includes purchased materials and material produced from own operations.
[p]Provisional.

Table 7. Capacity changes during 1975, cement plants

Company	Location	Net Increase (tons a year)	Approximate Cost ($ million)	Remarks
Canada Cement Lafarge Ltd.	St-Constant	525,000	25	Originally scheduled for completion in 1974.
	Exshaw	200,000	30	Actually on stream in early 1976.
Lake Ontario Cement Limited	Picton	850,000	22	Completion of a pre-heater kiln system.

Source: Mineral Development Sector, Department of Energy, Mines and Resources, Ottawa.

Outlook

Construction in Canada will continue to show an annual increase in value, and cement producers will have to compete with producers of all other building materials to obtain a share of the construction dollar. Not only is practical research in the use of cement-concrete needed, but effective advertising and public relations must be used to encourage acceptance of modular construction at a time when reasonably priced, attractive and convenient housing units are in short supply. In general, modest gains are expected in the near-term, with activity across the country expected to range from promising to cautious.

The availability of other construction materials has played a major role in determining the amount of cement required for construction. Projects have been delayed because of shortages of steel, rebar, gypsum products and other items, and shortages of certain materials could create problems again. Of particular concern in this regard will be sources of energy. The cement industry has long recognized the importance of fuel conservation, if for no other reason than that fuel costs have represented a major portion of its total operating costs. A voluntary commitment by the Canadian industry to reduce unit fuel consumption by 9 to 12 per cent by 1980 (with 1974 as the base year) has been undertaken. The already-established trend to dry processing and the use of preheaters will continue for new plants, while rehabilitation of older plants will continue to benefit from new technology. Rebuilding programs are costly, especially when they must be accomplished with no loss in production. The obvious incentives of cost savings must be attractive enough to warrant the expense and effort. The expense of adapting older facilities to meet newly imposed environmental control regulations can contribute to a decision in favour of a new plant — such decisions have forced a number of plant closures in the United States. Continued diversification and vertical integration by cement producers will eventually result in the write-off of some comparatively inefficient production capacity as the emphasis on a cement-concrete industry increases. Work stoppages have seriously delayed many construction projects. In general, labour relations in the construction industry have shown improvement, with a mature and rational approach to labour-management problems which, hopefully, will continue and thereby do much to reduce the cyclical aspects of the industry. The shortage of skilled labour could reach problem proportions for the construction industry, if not generally, certainly in some regions, as more and larger projects are undertaken.

The cement industry in Canada is capable of meeting the immediate demands on it and is in a position to expand in anticipation of even greater demand and to take advantage of foreign market openings should they be presented.

Although individual companies continue to conduct research relative to cement production, much experimentation concerning the use of cement and concrete is done through the Portland Cement Association (PCA), an industry-supported, nonprofit organization whose purpose is to improve and extend the uses of cement and concrete through scientific research and engineering fieldwork. The Association is active in all parts of Canada, and can offer detailed information on concrete use, design and construction from its regional offices.

Cement manufacture is energy-intensive. It is obvious that research should be concentrated in this area and specifically within the pyroprocessing sector where over 80 per cent of the energy is consumed. Raw material grinding and finish grinding are also being studied to determine optimum particle size for energy consumed.

In terms of the energy content in concrete structures and the energy requirements to service and maintain concrete structures they are not so energy-intensive as the plus 5 million BTU's per ton of cement would at first indicate.

Total value of construction expenditure in 1976 is estimated at about $31 billion, an increase of approximately 12 per cent over 1975. Because of inflationary factors, real growth is expected to be small. There will undoubtedly be regional weaknesses, in particular in Quebec province where construction for the Olympics will taper off. Engineering construction will continue reasonably strong with long range carry-over projects.

World review

Because of the direct relationship of cement, concrete, and construction, the consumption of cement can be monitored as an indication of a country's rate of development.

World production in 1975 was estimated to be 700 million metric tons, about the same as in 1974. Conservation of energy and raw materials within the cement industry is of world-wide concern and provides a theme around which major developments in the industry have taken place. Of particular note is the emphasis on blended cements, utilizing slag, ash and other byproducts. Even greater additions to production capacities than those witnessed during the past few years will be needed to meet demand in many developing countries. The following items, some of which were reported in *Rock Products* and/or *Pit and Quarry* magazines, are indicative of trends in the regions noted, but in no way represent a total coverage of world activity.

Asia. Iran's cement production in 1974 was recorded by the European Cement Association (Cembureau) as 4.5 million metric tons, over one third of total production in western Asia. Capacity increases in the form of two new plants and one expansion are scheduled for 1976. One new plant, Aria Cement Corp. at Isfahan, will produce slag cement from granulated blast furnace slag supplied by an adjacent iron works. Plant capacity is to be over 3 million metric tons a year.

The government of Iraq, whose cement production in 1974 is estimated at 1.8 million metric tons, has awarded a $225 million contract for the construction of a 2.3-million-ton-a-year plant to be located 100 miles south of Baghdad.

Table 8. Planned cement plant capacity changes (as of early 1976)

Company	Plant location	Net increase (tpy)	Expected date of completion	Approximate cost ($ million)	Remarks
Atlantic					
Canada Cement Lafarge Ltd.	Brookfield	262,000	1977	25	Capacity to be doubled.
Quebec					
Canada Cement Lafarge Ltd.	Montreal East	(500,000)	1976	13	General rehabilitation, two kilns to replace seven, wet process to dry process, effective capacity 500,000.
	Hull	(210,000)	1976	2	New finish grinding mills. Stopped clinker production at end of 1975.
Ontario					
St Mary's Cement Ltd.	St Marys	700,000	1976	30	New kiln (sixth) and new mill.
British Columbia					
Ocean Construction Supplies Ltd.	Vancouver	1,100,000	1978	90	New plant planned for Tilbury Island.
	Bamberton	(700,000)	1978		Clinker production to be phased out.
		652,000		160	

Source: Mineral Development Sector, Department of Energy, Mines and Resources, Ottawa.

Table 9. Canada, house construction, by province

	Starts			Completions			Under Construction		
	1974	1975	% Diff.	1974	1975	% Diff.	1974	1975	% Diff.
Newfoundland	4,911	5,342	+9	4,446	4,831	+9	4,173	5,107	+22
Prince Edward Island	1,334	847	−37	1,664	1,130	−32	860	314	−63
Nova Scotia	6,008	6,366	+6	6,604	6,249	−5	6,349	7,301	+15
New Brunswick	5,861	6,983	+19	6,812	5,804	−15	3,550	4,463	+26
Total (Atlantic Provinces)	18,114	19,538	+8	19,526	18,014	−8	14,932	17,185	+15
Quebec	51,642	54,741	+6	58,596	51,540	−12	31,487	31,805	+1
Ontario	85,503	79,968	−6	104,360	81,865	−22	78,517	75,690	−4
Manitoba	8,752	7,845	−10	12,164	8,760	−28	5,668	4,917	−13
Saskatchewan	7,684	10,505	+37	6,487	7,705	+19	5,001	7,728	+55
Alberta	19,008	24,707	+30	21,570	17,550	−19	9,940	16,909	+70
Total (Prairie Provinces)	35,444	43,057	+21	40,221	34,015	−15	20,609	29,554	+43
British Columbia	31,420	34,152	+9	34,540	31,530	−9	22,861	22,365	−2
Total Canada	222,123	231,456	+4	257,243	216,964	−16	168,406	176,599	+5

Source: Statistics Canada.

Saudi Cement Co. has contracted for a 1-million-metric-ton-a-year plant at Hofuf cement works at a cost of $85 million.

In Korea, Ssang Yong Cement Industries Co. Ltd. will expand its cement manufacturing capacity by more than 5 million metric tons a year. Kuan Hsi Cement Corp. plans to build a 1.2 million-ton-a-year plant at Kaohsiung at a cost of $40 million. The Republic of Korea produced 8.8 million metric tons in 1974.

Africa. At Constantine and at Beni Saf in Algeria, cement plants will be constructed for the Société Nationale des Matériaux de Construction by Creusot-Loire Enterprises of France, while Kawasaki Heavy Industries Ltd. of Japan and Marubeni Corp. will build a 1.1 million-ton-a-year plant at El Asnam.

Fives-Cail Babcock of France has been contracted to build a 1-million-tpy dry process plant at the site of the existing Zahana cement works near Otan, Algeria. A joint venture has been undertaken between Algeria and Morocco to construct a 1-million-ton-a-year cement plant at Oujda, Morocco.

In West Africa, Les Ciments de l'Afrique de l'Ouest has been formed by the Governments of Togo, Ghana and the Ivory Coast to build a 1.2-million-ton-a-year plant at Tabligo, Togo. The Associated Portland Cement Manufactures Ltd. (the Blue Circle Group) of Great Britain has the contract for engineering services.

Europe. M.A. Karageorgis, S.A. has contracted with Kaiser Engineers to manage engineering and construction for a 1-million-metric-ton-a-year cement plant at Messinia, Greece.

Cement-Roadstone Holdings of Dublin, Ireland plans to double the production capacity of its Platin cement plant to 1 million tons a year with the installation of a dry process kiln and twin four-stage suspension preheaters.

Table 10. Canada, production of concrete products

	1974	1975[p]
Concrete bricks (number)	173,351,839	130,124,689
Concrete blocks (except chimney blocks)		
Gravel (number)	257,615,334	226,039,774
Other (number)	42,672,314	39,305,525
Concrete drain pipe, sewer pipe, water pipe and culvert tile (short tons)	1,820,072	1,724,351
Other precast products (short tons)	139,524	160,690
Concrete, ready-mix (cubic yards)	17,437,320	16,554,144

Source: Statistics Canada.
[p]Preliminary.

In Belgium, S.A. Cimenteries C.B.R. has built its fifth cement plant. Three types of cement are produced by varying blends of clinker, slag and anhydrite at the new plant located at Ghent.

Oceania. Plans are already made to double the 500,000 tpy capacity of Cibinong Cement Co.'s new plant at Cibinong, Indonesia. The new plant, which cost $41.7 million, is jointly owned by Gypsum Carrier, a subsidiary of the Kaiser Cement and Gypsum Co. and Gresik Cement Co., an Indonesian government organization.

Table 11. Canada, construction spending by provinces, 1974-76

	1974[1]	1975[2]	1976[3]
	(millions of dollars)		
Newfoundland	607.0	626.2	740.6
Prince Edward Island	103.6	99.7	90.0
Nova Scotia	711.1	759.9	895.7
New Brunswick	755.3	854.3	859.8
Quebec	5,598.2	6,918.7	7,477.3
Ontario	8,501.3	9,003.9	9,796.5
Manitoba	982.0	1,045.1	1,169.1
Saskatchewan	857.7	1,079.5	1,318.9
Alberta	2,961.6	3,834.1	4,827.1
British Columbia, Yukon and Northwest Territories	3,615.3	3,912.0	4,273.9
Canada	24,693.1	28,133.4	31,448.9

Source: Statistics Canada.
[1]Actual; [2]Preliminary; [3]Forecast.

Construction of a 600,000 tpy cement manufacturing plant at Cilacap in Central Java, Indonesia has begun under an agreement with Mitsui & Co., Ltd., Japan, Onoda Cement Co., Japan and P.T. Gunnung Ngadeg Djaja of Indonesia which has established P.T. Senen Nusantara in Jakarta as a cement producing venture.

Cyprus Hawaiian Cement Corp., a subsidiary of Cyprus Mines Corporation has completed expansion of its plant to 275,000 tpy at a cost of $7.5 million.

South America. Cimento Santa Rita S.A. is installing a 2,000-metric-ton-a-day suspension preheater kiln system at Sao Paulo, Brazil. Start up is scheduled for 1976.

A two-line wet process cement plant will be built at Cartagena, Colombia for Compania Colombiana de Clinker S.A. Major equipment will be supplied by Allis-Chalmers Corporation for the 2,000 metric-ton-a-day plant under a $6.3 million contract.

Allis-Chalmers is also supplying equipment and engineering services for a 1,500 mtpd plant at Guayaquil, Ecuador under a $10 million contract with La Cemento Nacional C.E.M. for a suspension preheater cement manufacturing system.

Table 12. World production of cement, 1964 and 1974

	1964	1974[p]	Increase
	(thousand short tons)		(%)
U.S.S.R.	71,577	126,766	77
United States	72,453	82,888	14
Japan	36,355	80,592	122
Italy	25,177	40,024	59
West Germany	37,073	39,658	7
France	23,740	35,794	51
People's Republic of China	11,574	29,762	157
Spain	9,370	26,081	178
United Kingdom	18,702	19,600	5
Poland	9,657	18,480	91
Brazil	6,133	16,446	168
India	10,681	15,722	47
Rumania	5,238	12,340	136
Mexico	4,869	11,572	138
Canada	7,847	11,436	46
Other countries	107,726	209,175	94
Total	458,172	776,336	

Sources: Statistics Canada; U.S. Bureau of Mines *Minerals Yearbook, 1966* for 1964 and U.S. Bureau of Mines *Mineral Trade Notes, Vol. 72, No. 12,* December 1975.
[p]Preliminary.

Cementos Lima S.A. is doubling capacity at its Atacongo plant to 6,000 mtpd at a cost of $100 million. Engineering is by Holderbank Consulting Ltd., who also constructed, within a 24-month period. a 2,600 metric-ton-a-day plant for Cimento Nacional de Mines, S.A. at Pedro Leopoldo, Brazil.

Central America. Dominican Republic, Jamaica and Panama are each planning to construct a new cement plant, while two plants in Mexico are undergoing major expansion.

North America. In 1975 about 5 million tons a year was added to United States cement production capacity, while about 1.5 million tons was removed by plant closures. New plants were constructed at Brooksville, Florida (Florida Mining & Materials Corp.), at Louisville, Nebraska (Ash Grove Cement Co.), at Roanoke, Virginia (Citadel Cement Corporation) and at Joppa, Illinois (Missouri Portland Cement Co.). Seven major expansions included new kilns and new mills.

During 1976 capacity increases will total approximately 3.4 million tons a year. Three essentially new plants at old locations are now under construction — Citadel Cement Corp., Demopolis, Alabama; South

Table 13. Apparent consumption of cement by the leading producers, 1974

	Production[p]	Apparent Consump-tion	lb/ capita
	(thousand short tons)		
U.S.S.R.	126,766	123,336	979
United States	82,888	78,197	739
Japan	80,592	77,457	1,409
Italy	40,024	39,542	1,433
West Germany	39,658	37,695	1,215
France	35,794	34,489	1,308
People's Republic of China	29,762	25,574	62
Spain	26,081	24,417	1,383
United Kingdom	19,600	19,459	695
Poland	18,480	19,678	1,169
Brazil	16,446	16,575	318
India	15,722	15,719	53
Rumania	12,340	10,141	964
Mexico	11,572	11,337	390
Canada	11,436	10,740	955
Other countries	209,175		
Total	776,336		

Sources: Statistics Canada, U.S. Bureau of Mines *Mineral Trade Notes, Vol. 72, No. 12,* December 1975, Cembureau Statistical Review, 1974.
[p] Preliminary.

Table 14. Cement production per capita, leading countries, 1964 and 1974

	1964	1974	Increase
	(pounds)		(%)
Bahamas	. .	7,940	. .
Qatar	. .	2,444	. .
Luxembourg	1,370	2,394	75
Austria	1,151	1,877	63
Switzerland	1,646	1,798	9
Greece	692	1,725	149
Belgium	1,374	1,678	22
Spain	591	1,481	151
Japan	743	1,470	98
Norway	921	1,470	60

Sources: Calculated from production figures in U.S. Bureau of Mines *Minerals Yearbook 1966 and 1974,* and population statistics in United Nations Monthly Bulletin of Statistics, 1966 and 1976.
. . Not available.

Table 15. Apparent consumption of cement, 1974 — leading consumers

	Consumption	Consumption per capita
	(000 short tons)	(lb)
U.S.S.R.	123,336	979
United States	78,197	739
Japan	77,457	1,409
Italy	39,542	1,433
West Germany	37,695	1,215
France	34,489	1,308
People's Republic of China	25,574	62
Spain	24,417	1,383
Poland	19,678	1,169
United Kingdom	19,459	695
Brazil	16,575	318
India	15,719	53
Mexico	11,337	390
East Germany	10,803	1,255
Czechoslovakia	10,766	1,466
Canada	10,740	955

Source: Cembureau Statistical Review, 1974.

Table 16. Per capita apparent consumption of cement, 1974 — leading countries.

	Apparent Consumption lb/capita
Qatar	5,226
Andorra	2,481
Libyan Arab Republic	2,425
Oman — United Arab Emirates	2,293
Luxembourg	2,269
Kuwait	2,134
Bermuda	1,985
Guam	1,958
Switzerland	1,771
Austria	1,768
Iceland	1,715
New Caledonia	1,471
Czechoslovakia	1,466

Source: Cembureau Statistical Review, 1974.
Note: Canada ranks 35th.

Dakota Cement, Rapid City, South Dakota and Universal Atlas Cement Division of United States Steel Corporation, Leeds, Alabama. Major expansions involving new kilns or mills will be completed by Atlantic Cement Company, Inc., at Ravena, New York, by Lehigh Portland Cement Co. at Mitchell, Indiana and by National Cement Co. at Ragland, Alabama. Programs scheduled for completion in 1976 will result in the expenditure of over $160 million.

To meet the projected demands of industrial expansion in the late 1950's, many cement companies added to their production capacities, with the result that the North American industry developed a total capacity in excess of that required to meet demand. The cement industry had to "sell" its product by providing services and technical assistance to consumers and by researching new and competitive construction uses for concrete. Vertical integration, diversification and mergers, although always a part of the cement industry, have become more common on the North American scene.

About 15 per cent of world cement production comes from North America, with the United States contributing nearly 80 per cent of the total, and Canada and Mexico following in that order. Virtually all plants have undergone, or are undergoing, some modernization and improvement of dust-collecting facilities because of new or anticipated pollution-control standards. Canada's cement capacity, together with that planned to come on stream during the next two years, permits export of clinker and cement without harm to domestic markets. A realistic, practical, production capacity, as opposed to a listed capacity, would probably indicate surprisingly little excess production capability in Canada's cement industry. This would be especially obvious in certain regions of the country, and at the height of activity during a construction year.

In the United States, low prices, high costs, low profit margins and under capacity, complicated by a downturn in construction activity and intentions, are of major concern to the cement industry. The energy situation will undoubtedly have an influence on these items either directly or indirectly, as will environment regulations.

Table 17. Cement, world production

Country	1974	1975[e]
	(thousands short tons)	
U.S.S.R.	126,766	117,000
United States (incl. Puerto Rico)	82,888	71,200
Japan	80,592	67,700
Italy	40,024	33,600
West Germany	39,658	33,300
France	35,794	30,100
People's Republic of China	29,762	30,000
Spain	26,081	21,900
United Kingdom	19,600	16,500
Canada (shipments)	11,436	10,763
Other Free Countries	213,857	178,237
Other Communist Countries	69,878	66,550
World total	776,336	676,850

Sources: U.S. Bureau of Mines, Commodity Data Summaries, January, 1976. For Canada, Statistics Canada.
[e]Estimated

Table 18. Canada, value of construction by province, 1974-75

	1974[1]			1975[2]		
	Building Construction	Engineering Construction	Total	Building Construction	Engineering Construction	Total
	(thousands of dollars)					
Newfoundland	347,328	259,641	606,969	329,290	296,870	626,160
Nova Scotia	407,555	303,545	711,100	435,847	324,059	759,906
New Brunswick	387,841	367,477	755,318	414,393	439,961	854,354
Prince Edward Island	78,767	24,886	103,653	67,676	32,048	99,724
Quebec	3,733,943	1,864,242	5,598,185	4,428,346	2,490,370	6,918,716
Ontario	5,904,100	2,597,178	8,501,278	5,747,728	3,256,150	9,003,878
Manitoba	586,496	395,525	982,021	551,396	493,660	1,045,056
Saskatchewan	491,406	366,261	857,667	634,208	445,317	1,079,525
Alberta	1,309,497	1,652,073	2,961,570	1,571,101	2,263,029	3,834,130
British Columbia, Yukon, Northwest Territories	1,998,341	1,616,968	3,615,309	2,168,935	1,743,061	3,911,996
Canada	15,245,274	9,447,796	24,693,070	16,348,920	11,784,525	28,133,445

Source: Statistics Canada.
[1]Actual. [2]Preliminary.

Table 19. Value of construction in Canada, 1973-75

	1973	1974	1975[p]	Change 1974-75
	(millions of dollars)			(%)
Building construction				
Residential	7,165.3	8,460.7	8,718.6	+ 3.1
Industrial	1,148.6	1,532.4	1,394.8	− 9.0
Commercial	2,211.5	2,969.1	3,518.8	+18.5
Institutional	1,200.0	1,382.7	1,539.3	+11.3
Other building	679.7	900.4	1,177.4	+30.8
Total	12,405.1	15,245.3	16,348.9	+ 7.2
Engineering construction				
Marine	147.7	214.5	212.4	− 1.0
Highways, aerodromes	1,825.8	2,136.9	2,620.3	+22.6
Waterworks, sewage systems	791.1	1,078.5	1,264.0	+17.2
Dams, irrigation	85.6	111.2	120.1	+ 8.0
Electric power	1,520.4	1,845.6	2,584.5	+40.0
Railway, telephones	806.0	1,039.9	1,201.4	+15.5
Gas and oil facilities	1,499.4	1,709.8	1,964.1	+14.9
Other engineering	1,092.6	1,311.4	1,817.7	+38.6
Total	7,768.6	9,447.8	11,784.5	+24.7
Total construction	20,173.7	24,693.1	28,133.4	+13.9

Source: Statistics Canada.
[p] Preliminary.

Tariffs

Canada

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
		(c)	(c)	(c)	(c)
29000-1	Portland and other hydraulic cement, nop; cement clinker per 100 lb	free	free	6	free
29005-1	White, nonstaining portland cement, per 100 lb	4	4	8	2⅔

United States

Item No.		On and After Jan. 1, 1972
		(¢ per 100 lb incl. weight of container)
511.11	White nonstaining portland cement	1
511.14	Other cement and cement clinker	free
		(%)
511.21	Hydraulic cement concrete	free
511.25	Other concrete mixed	7.5

Sources: For Canada, the Customs Tariff and Amendments Department of National Revenue, Customs and Excise Division, Ottawa. For United States, Tariff Schedules of the United States Annotated (1976), TC Publication 749.

Cesium

J.G. GEORGE

Cesium is a soft, silvery white, ductile metal with a melting point of 28.5°C, a boiling point of 705°C, a density of 1.87 grams per cubic centimetre at 20°C and an atomic weight of 132.91. It is one of the three metals (the others are mercury and gallium) which are liquid at room temperature. Cesium is the fortieth most common element in the earth's crust, about as abundant as germanium. It is the eighth lightest metallic element but, of the five naturally-occuring alkali metals, cesium is the most electropositive, has the highest density, highest vapour pressure, lowest boiling point and lowest ionization potential. Because of these properties cesium is used in preference to other alkali metals in such space-age applications as space propulsion and energy conversion.

Cesium emits electrons when exposed to visible light, ultraviolet light or infrared light. Precautions must be taken in handling, transporting and storing cesium metal because in air or water it is very reactive chemically; and when exposed to a combination of the two it reacts violently. The vigour of the reaction of cesium with water is evidenced by the fact that the metal reacts with ice at all temperatures above -116°C, liberating hydrogen. The reaction with cold water is explosive. Cesium is an efficient scavenger for traces of oxygen in highly evacuated containers. It resembles potassium and rubidium in the metallic state and is similar to them in chemical behaviour but oxidizes more readily than any of the other alkali metals.

Occurrences and recovery

Of the naturally-occurring alkali metals, cesium is the least abundant. It is widely distributed in the earth's crust and, usually, in low concentrations. It occurs in certain granites and granitic pegmatites, with granites having been estimated to contain an average of about one part per million of cesium. Greater concentrations of cesium are found in lepidolite, carnallite, beryl, leucite, spodumene, petolite and related minerals. Although commercial quantities of cesium have been obtained from both lepidolite and carnallite, the most important economic source of the metal is the rare mineral pollucite. Pollucite is usually found in complex, generally well-zoned pegmatite dykes that are rich in lithium minerals, especially lepidolite.

Pollucite, a mineral resembling quartz in lustre and transparency, is a hydrated silicate of aluminum and cesium ($Cs_2O.Al_2O_3.4SiO_2$) with the theoretically pure mineral containing 45 per cent cesium oxide (Cs_2O). Naturally-occurring pollucite usually contains from 6 to 32 percent CS_2O. The higher-grade variety of pollucite has a specific gravity of 2.9 and a hardness of 6.5 on Mohs' scale. It is colourless to white, or greyish or pinkish white.

The largest known reserves of pollucite are: 50,000 tons* in the Karibib area in South-West Africa, 150,000 tons in the Bikita district of Rhodesia, and 490,000 tons at the mine of International Chemalloy Corporation at Bernic Lake in southeastern Manitoba, Canada, about 110 miles northeast of Winnipeg. Mozambique also has pollucite deposits but their quantity and grade are not known. Other deposits are found in the island of Elba, at Veratrask, Sweden, at West Paris in Maine, and in the Black Hills near Custer, South Dakota. A second Canadian occurrence is at the Valor property in Lacorne Township, northwestern Quebec, formerly owned by Massval Mines Limited.

The only known Canadian cesium-bearing deposit of economic importance is that of International Chemalloy Corporation. The property is operated by Tantalum Mining Corporation of Canada Limited which is 50.1 per cent owned by International Chemalloy Corporation; 24.9 per cent by Kawecki Berylco Industries, Inc.; the remaining 25 per cent interest being held by the Manitoba Development Corporation (MDC) which is the investment agency of the Manitoba government. The pollucite ore zones are separate from the company's tantalum and lithium orebodies (although these do contain low cesium values) which are contained in the same deposit. The pollucite unit consists of three sheet-like bodies, the largest of which ranges up to 45 feet in thickness and lies in the south-east quadrant of the pegmatite. As of December 31, 1975 the company's

* The term "ton" refers to the short ton of 2,000 pounds avoirdupois throughout.

cesium reserves consisted of 300,000 tons of pollucite averaging 23 per cent. Cs_2O in the main zone, 30,000 tons averaging 20 per cent Cs_2O or better in the western zone and 160,000 tons grading 5 per cent Cs_2O in the lower and western zones. The main zone is open to the south and could be extended by further drilling. In addition, there are large areas of the pegmatite body containing quantities of pollucite averaging 1 to 3 pounds of Cs_2O a ton which have not yet been assessed for ore reserves. Also, deeper holes below the main pegmatite body have indicated a second sill approximately 100 feet below the main body which contains pollucite, tantalite, and spodumene mineralization.

At the Valor property in northwestern Quebec, masses of pollucite up to five feet in maximum exposed dimension are scattered through part of a lenticular core zone of a complex dyke. The zone consists chiefly of quartz, cleavelandite and spodumene, with irregular masses and disseminations of lepidolite.

Ores naturally rich in pollucite have been upgraded experimentally with some success, but satisfactory methods to concentrate pollucite economically from low-grade ores have not yet been developed. The United States Bureau of Mines has, however, developed experimentally a froth flotation process for concentrating pollucite ore. When applied to a low-grade cesium ore from the state of Maine grading about 8 per cent Cs_2O, the ore was upgraded to over 21 per cent Cs_2O with a cesium recovery of almost 87 per cent. Commercial concentrates and direct shipping ore usually grade in excess of 20 per cent Cs_2O. At the present time all cesium raw materials requirements of the United States are met from imports.

Thermochemical and hydrometallurgical methods are used for the production of cesium salts and compounds from pollucite ore. Cesium metal can be produced by direct thermochemical reduction of pollucite ore under vacuum or in an atmosphere of an inert gas (argon or helium), or by thermo-chemical reduction of a cesium compound under vacuum. Frequently-used methods of producing elemental cesium are the heating of cesium carbonate with magnesium at about 675°C under hydrogen, or the heating of cesium chloride with calcium at the same temperature under vacuum. In both cases the metal is condensed from the vapour state in the absence of air, frequently under an inert oil to protect it from reaction with the atmosphere. Cesium metal has also been produced on a laboratory scale by electrolysis but this method of recovery has not yet proved economically feasible.

Production and consumption

Little statistical data is available on the production and consumption of pollucite or cesium metal and compounds. Annual world mine production of pollucite ore was estimated at only 20 tons as recently as 1968. Since then, an increasing demand has resulted in a significantly greater output of pollucite. In 1975 shipments from Chemalloy's Bernic Lake property totalled 747,279 pounds of pollucite with an average Cs_2O content of 23.2 per cent. Of the total pollucite shipments 554,096 pounds were exported to Russia, 191,010 pounds to the United States and 2,173 pounds to Japan, all in the form of crushed ore.

Until 1968, world consumption of cesium metal and compounds was probably less than ten tons a year. In the past few years there has been a major increase in consumption mainly because of the increasing quantities of cesium compounds used in experimental magnetohydrodynamic (MHD) electrical power generators. The U.S.S.R. is probably the largest consumer of cesium in the world. It has imported almost 1,100 tons of pollucite from Canada over the last six years, which suggests an annual consumption in the range of 60,000 pounds of cesium unless some of these imports were put into stockpile. The U.S.S.R. is doing extensive research in MHD generation of electricity and cesium oxide is used as the seed in the process.

Uses

At present there are no large-scale commercial uses for cesium. Most of the metal and its compounds are currently consumed in the developmental research of thermionic power conversion units, ion propulsion and MHD electrical power generators. In MHD pilot plants, which make use of cesium's ionization potential, a fuel (coal, oil or gas) is burned. The hot gas is seeded with an easily-ionized element such as cesium or potassium, or mixed cesium-potassium, in the form of carbonates to increase its conductivity. The ionized gas (plasma) is accelerated through a chamber surrounded by a strong magnetic field resulting in the generation of electricity which is drawn off through electrodes placed in the channel. The amount of power generated depends on the degree of ionization, the velocity of the plasma, and the magnetic field strength. Significant increases in efficiency and cheaper power with little or no pollution (cesium carbonate when used as the "seed" is said to scrub out the harmful sulphur oxides produced by the burning coal or char) can be expected from MHD generators. Cesium salts as well as the metal are possible additives for MHD applications which are still in the research and development phase. While alternative materials, such as rubidium, potassium and sodium, may be used in the process, present knowledge is that cesium compounds are the most efficient.

In thermionic converters, the heat from nuclear reaction radiates to a surrounding metal (cathode) which emits large masses of electrons. The electrons travel through a space filled with a gas such as cesium vapour to an anode, which then has a potential with respect to the cathode, and electricity can flow through a circuit joining the anode and cathode. The most important factor limiting the efficiency of thermionic generators is the "space charge" effect. It is caused by the mutual repulsion of electrons wherein electrons in the space between the electrodes repel those emerging from the cathode and return them to the cathode. Ionized cesium gas is used to electrically neutralize the space charge. Nuclear heating is used in thermionic converters as it can serve as the source for the high temperature (1,900°C) required.

In spacecraft, cesium is used in the ion-propelled engines. Vapourized cesium is ionized while passing through a heated porous tungsten disc. The cesium ions become positively charged and an electric field accelerates the positive ions to a velocity of some 300,000 miles per hour. The high-velocity ions are neutralized by the injection of electrons and then exhausted through a nozzle to develop thrust. Since ion propulsion is essentially a low-thrust system, one of its potential uses lies either in the maintenance of orbiting space vehicles in their orbits, or in the movement of such vehicles from one orbit to another. An ion engine could be used to move a vehicle from earth orbit to Mars orbit, for example, but could not be used for takeoff from, or for landing on, either planet.

Other commercial applications for cesium include its use in photomultiplier tubes, vacuum tubes, scintillation counters, magnetometers, infrared lamps, pharmaceuticals and as reagents in microanalysis. Another commercial outlet is in photoelectric cells, developed in the early 1930's, in which the photoemissive properties of cesium are utilized. In photoelectric cells light energy, falling on the cesium cathode, causes electrons to be emitted. Light-sensitive cathodes of cesium on a conducting base, such as silver, may be constructed for photocell use, and many alloys of cesium are also photoelectric. The compound $SbCs_3$ has significantly high photoelectric sensitivity. An alloy of cesium and silver is used in the emitron or "electric eye" used in television. Cesium is used as an absorbent to remove impurities at carbon dioxide purification plants and acts as a catalyst in various hydrogeneration and polymerization processes. The metal may also act as a scavenger of gases and other impurities in chemical processing and in both ferrous and nonferrous metallurgy.

In biological research, concentrated cesium chloride solutions are used for density gradient ultracentrifuge separation of DNA, viruses and other large molecules. This could be an important use for cesium and may become one of its largest end uses, apart from research into MHD power generation. Rubidium salts are sometimes used instead of, or in conjunction with, cesium chloride for ultracentrifuge gradient density separations. Cesium bromide is used in the manufacture of optical crystals. Cesium fluoride finds application as a fluoridating agent in organic syntheses, and cesium hydroxide with rubidium hydroxide can be used in place of lithium hydroxide in alkaline storage batteries for operation at temperatures as low as -50°C. Cesium phosphate is used in the form of mixed crystals, with rubidium and/or ammonium salts, for piezoelectric purposes. Substitutes for cesium in some of its applications are potassium, magnesium oxide, and rubidium which have properties similar to those of cesium or its compounds.

Outlook

So far, the market for cesium metal and compounds has been quite limited as its high cost and extreme reactivity restricts its use to applications where its unique properties are important. Its relatively high cost also encourages the substitution of other materials wherever possible. The greatest potential for sharply increased consumption of cesium appears to be in a technological breakthrough in the research and development of a power generating process using cesium.

Grades, specifications and prices

Although cesium metal is produced in 99, 99.5, 99.9 and 99.97 per cent purities, the two main grades in which it is usually marketed are: standard, with a minimum cesium content of 99.5 per cent; and high purity, with a minimum cesium content of 99.9 per cent. Nonmetallic impurities, particularly oxygen, critically affect the corrosive properties, and hence the utility, of cesium metal. Cesium salts are also available and include: acetate, bromide, carbonate, chloride, chromate, fluoride, hydroxide, iodide, nitrate and sulphate. In 1961 the standard specification for technical-grade cesium salts was raised from 97 to 99 per cent pure. Cesium is also available in a series of oxides.

Recent nominal quotations for raw pollucite ore of good grade and quality vary between about 50¢ and 75¢ a pound of contained Cs_2O. Cesium salts sell for about $25 to $40 a pound depending on the type of salt, grade and quantity purchased. Cesium metal of 99+ per cent purity has been quoted at $100 to $375 a pound, depending on the quantity and grade purchased. Three United States companies that produce cesium chemicals are: Kawecki Berylco Industries, Inc., Kerr-McGee Corporation, and Great Western Inorganics, Inc. (formerly Rocky Mountain Research, Inc.).

Tariffs

Canada

Item No.	British Preferential	Most Favoured Nation	General	General Preferential
92805-1 Cesium	10%	15%	25%	10%
93819-1 Compounds of cesium	10%	15%	25%	10%

United States

Item No.	Noncommunist countries	Communist countries except Yugoslavia
415.10 Cesium	8.5% ad. val.	25% ad. val.
418.50 Cesium chloride	6.0% ad. val.	25% ad. val.
418.52 Other cesium compounds	5.0% ad. val.	25% ad. val.

Sources: For Canada, the Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa. For United States, Tariff Schedules of the United States Annotated (1976), T.C. Publication 749.

Chromium

R. JOHNSON

Canada has no economically mineable deposits of chromite (chromium ore). Following the closure of Union Carbide Canada Limited's ferrochromium plant in 1974, the only products made in Canada that contain substantial amounts of chromium are chromium and chromium-magnesite refractories. Demand for chromium products in Canada dropped sharply in 1975, reflecting Canada's economic downturn.

The chromite market was weak in 1975. However, despite this weakness, prices continued to rise through 1975 as developments stemming from the political situation in southern Africa continued to create uncertainty in world chromite markets. As a measure of the weakness of the market, ferrochromium prices remained stable or declined during the year in spite of the rising price for chromite.

The outlook for chromium hinges in large part on the evolving political situation in southern Africa. In 1976, demand for chromium products is not expected to be high, and as a result, the market is expected to be fairly stable. Any significant recovery will, however, likely trigger further price increases and lead to a general shortage of chromite.

Canada

There are two principal areas of chromite mineralization in Canada; the Bird River area in Manitoba and the Eastern Townships in Quebec. The Bird River deposits are a continuous band of chromite mineralization, similar in type to the important chrome deposits in Rhodesia and the Republic of South Africa. However, most of the mineralization is low-grade, 10 to 20 per cent chromic oxide (Cr_2O_3) and has a low iron-to-chromium ratio. This is undesirable, in that the ores are difficult to beneficiate to a marketable product. The Ontario Research Foundation has developed a process for upgrading the Bird River chromite to a marketable product and partially as a result of this, the Manitoba Department of Mines, Resources and Environmental Management is currently conducting a reevaluation of the Bird River deposits. Deposits in the Eastern Townships are discontinuous, or podiform, deposits. These deposits were exploited earlier in the century and during the Second World War. While these deposits are generally satisfactory in grade and composition, the tonnages are too small to be considered economical. The large number of claim owners in this area discourages major efforts to determine if there are larger deposits at depth.

Union Carbide Canada Limited, which was Canada's only producer of ferrochromium, closed its Welland, Ontario ferroalloy plant in late 1974. The seven furnaces in the Welland plant are small and outdated, and the cost of installing pollution control equipment would make the operations uneconomic. The ferrochromium furnaces were to be replaced by a large ferro-manganese furnace, but, since Union Carbide was unable to obtain a long-term contract for electrical power from Ontario Hydro, the ferro-manganese furnace was subsequently located at Beauharnois in Quebec. Union Carbide did, however, continue to ship ferrochromium from accumulated stocks in 1975.

Canadian consumption of ferrochromium in 1975 was an estimated 28,000 tons* (gross weight) compared with 34,366 tons in 1974. The principal consumers of ferrochromium in Canada are: Atlas Steels Division of Rio Algom Limited, Colt Industries (Canada) Ltd., The Steel Company of Canada, Limited, The Algoma Steel Corporation, Limited and several iron and steel foundries. In recent years, the ratio of high-carbon ferrochrome to low-carbon ferrochrome consumed has been about 2:1. Atlas Steels, Canada's largest producer of stainless steel, announced that its present melt shop at Welland, will be replaced by a new one in 1977 that will increase ingot capacity to 320,000 tons a year from the current 250,000 tons a year. This will lead to increases in both stainless steel and ferrochromium consumption.

Canadian consumption of chrome ore in 1975 was 40,554 tons, compared with 66,658 tons the previous year. The decrease in consumption was largely because of the closure of Union Carbide's ferroalloy plant at Welland. The two major consumers in 1975 were

* The short ton of 2,000 pounds is used throughout unless otherwise stated.

Table 1. Canada, chromium trade and consumption, 1974-75

	1974		1975p	
	(short tons)	($)	(short tons)	($)
Imports				
Chromium in ores and concentrates				
United States	24,319	1,907,000	14,392	1,205,000
Philippines	3,757	301,000	10,559	827,000
Cyprus	975	98,000	4,662	527,000
South Africa	2,669	125,000	3,068	185,000
Total	31,720	2,431,000	32,681	2,744,000
Ferrochromium				
Republic of South Africa	30,482	8,098,000	22,238	11,069,000
Brazil	5,596	2,795,000	14,308	5,524,000
United States	4,842	1,426,000	5,318	4,565,000
Other countries[1]	1,400	913,000	3,451	4,379,000
Total	42,320	13,232,000	45,315	25,537,000
Chromium sulphates, including basic				
United States	961	332,000	1,423	552,000
United Kingdom	106	31,000	242	90,000
People's Republic of China	2	1,000	—	—
Total	1,069	364,000	1,665	642,000
Chromium oxides and hydroxides				
United States	1,000	969,000	818	918,000
France	389	314,000	119	117,000
United Kingdom	110	86,000	41	52,000
Other countries[2]	60	63,000	55	82,000
Total	1,559	1,432,000	1,033	1,169,000
Chrome dyestuffs				
Italy	—	—	12	62,000
West Germany	15	85,000	4	31,000
United States	31	77,000	9	30,000
Japan		4,000	1	10,000
Other countries[3]	3	18,000	3	15,000
Total	49	184,000	29	148,000

Source: Statistics Canada.
[1]Includes United Kingdom, Greece, Sweden, Norway, Switzerland, Japan. [2]Includes West Germany, People's Republic of China and Japan. [3]Includes Switzerland, Netherlands and United Kingdom.
pPreliminary; — Nil.

Canadian Refractories Division of Dresser Industries Canada, Ltd., and General Refractories Company of Canada Limited, both of which manufacture refractories.

At present there is only one important consumer of chromium metal in Canada — Deloro Stellite Division of Canadian Oxygen Limited, Belleville, Ontario. However, The International Nickel Company of Canada, Limited (Inco) plans to build a rolling mill at Sudbury, Ontario. The capacity is estimated to be in the order of 20 million pounds of strip a year made from nickel-copper alloy powders. A number of nickel alloys contain chromium, and it is possible that chromium metal consumption in Canada will increase significantly on completion of the plant in 1977.

Canadian imports of ferrochrome will rise as Union Carbide's stocks become depleted. Demand is expected to rise to about 50,000 tons a year by 1980 and the bulk of the imports will probably come from the Republic of South Africa. If Inco's new rolling mill

Table 2. Canada, chromium trade and consumption, 1966-75

	Imports		Exports	Consumption[2]	
	Chromite[1]	Ferro-chromium[2]	Ferro-chromium[2]	Chromite	Ferro-chromium
	(short tons)		(short tons)	(short tons)	
1966	20,880	12,536	35	64,550	17,200
1967	34,485	21,740	—	70,549	19,557
1968	22,401	15,045	1	77,075	45,696
1969	41,924	25,123	. .	68.484	25,035
1970	30,445	22,943	. .	61,963	31,257
1971	32,716	39,906	. .	61,313	22,861
1972	24,728	15,204	. .	62,712	24,975
1973	27,597	38,280	. .	38,030	28,380
1974	31,720	42,320	. .	66,658	34,366
1975^p	32,681	45,315	. .	40,544	. .

Source: Statistics Canada.
[1]Chromium content. [2]Gross weight.
^{p}Preliminary; — Nil; . . Not available.

does utilize chromium powders, the probable source of the imports will be the United States.

Grades of ore

The only commercially important ore of chromium (Cr) is chromite. Chromite ores contain varying amounts of iron (Fe), magnesium (Mg) and aluminum (Al). The general formula of chromite is $(Fe,Mg)O(Cr,Fe,Al)_2O_3$. There are three principal grades of ore: metallurgical, refractory and chemical.

World developments

World production of chromite (chrome ore) contained an estimated 3.31 million metric tons of Cr_2O_3 in 1975, an increase of 7.8 per cent from the previous year. The largest producers of metallurgical-grade chromite are: Rhodesia, the Republic of South Africa, Turkey and the U.S.S.R.; the most important producer of refractory-grade chromite is the Philippines; and the dominant producer of chemical-grade chromite is the Republic of South Africa.

Chromite problems in southern Africa have been further aggravated by the closure of the Moçambique ports of Lourenco Marques and Beira to Rhodesian traffic. Beira handled almost all chromite exports. The closure of these ports to Rhodesian goods will certainly limit the amount of chromite that can be exported and may even serve to reduce Rhodesian exports. There are alternate transportation routes available through the Republic of South Africa; however, the ability of these routes to handle the volume of Rhodesian imports and exports is questionable.

Since the imposition of United Nations sanctions against Rhodesia in 1966 few details on Rhodesian chromite production have been made available. The principal producers of chromite are subsidiaries of companies based in the United States and the United Kingdom. The principal producers are: Rhodesia Chrome Mines Ltd., African Chrome Mines Ltd., Union Carbide Rhomet (Pvt) Limited and Rio Tinto (Rhodesia) Ltd. In 1975 a new ferrochromium plant was scheduled to come on stream at Rio Tinto (Rhodesia) Ltd's industrial complex in the midlands area. No other developments are known to have occurred.

The Republic of South Africa has approximately 70 per cent of the world's known reserves of chromite. The ores are, however, generally friable and have a lower chromium-to-iron ratio than ores found in Rhodesia, Turkey and the U.S.S.R., its major competitors. The Republic of South Africa's enormous reserves are the basis for optimism among its producers. Production in 1975 totalled some 2.1 million metric tons and domestic producers expect production to rise to over 5 million metric tons by 1980. A large part of this increased production is earmarked for the rapidly growing domestic ferrochromium industry.

Two new ferrochromium plants, each with a planned capacity of 120,000 metric tons a year, are scheduled to come on stream in 1976 and 1977. The two new plants are joint ventures of Republic of South Africa firms and foreign firms. The first is a joint venture of General Mining and Finance Corporation Ltd. and Union Carbide Corporation. The ore to supply the plant will come from an expansion of General Mining's chromite mines in the Steelport area. Union Carbide has contracted to buy part of the output for delivery to its customers in the United States. The second plant is a joint venture of Johannesburg Consolidated Investment Company and Showa Denko Kahan Kaisha, with British Steel Corporation being a junior partner. Both Showa Denko and British Steel have contracted to buy part of the plant's output. Gold Fields of South Africa

Table 3. Specifications and grades of chromite

Grade	Chromic Oxide (Cr_2O_3) content	Cr:Fe ratio	Other requirements
Metallurgical	>46%	>3:1	< 5% silica (SiO_2)
Refractory	35-40%	>3:1	< 6% silica, alumina (Al_2O_3) and chromic oxide content should be 57-63% < 12% iron (FeO)
Chemical	>44%	>1.5:1	< 15% alumina < 5% silica < 20% iron

Source: Mineral Development Sector, Department of Energy, Mines and Resources, Ottawa.

Ltd. is presently carrying out a feasibility study on a third plant, which could be operational by 1980. In addition to these new plants, there are also two expansions under way or near completion. Ferrochromium facilities will be expanded at Amcor Ltd. and Feralloys Ltd., a subsidiary of The Associated Manganese Mines of South Africa Limited. Amcor will begin production of 60,000 tons a year of ferrochromium, with the production being under long-term contract to two Japanese consumers. Negotiations for installation of a second furnace are under way with Japanese consumers. Feralloys' expansion is scheduled for completion in 1976. Should all envisioned projects and expansions take place, the Republic of South Africa could produce upwards of 1,000,000 metric tons of ferrochromium a year by 1980.

While the Republic of South Africa has the capability of producing 5,000,000 metric tons a year of chromite and 1,000,000 metric tons a year of ferrochromium, there are several factors beyond the control of the country that may realistically limit the growth of the domestic chromite and ferrochromium industries. The root of the problem is a long-standing arrangement whereby the Republic of South Africa routes a proportion of its chromite exports through the port of Lourenco Marques. With this outlet available there has been little reason in the past to develop handling facilities for chromite at ports in the Republic of South Africa. As a result, virtually all chromite and ferrochromium were shipped through the port of Lourenco Marques. This dependence on a single port was further emphasized by the fact that chromite must be kept clean, and this restricted the use of other ports because it imposed restrictions on the use of bulk mineral handling terminals. Also, as a result of the closure of the Rhodesia-Moçambique border, a sizeable portion of the spare rail and port capacity of Lourenco Marques has been lost to the handling of goods destined for Rhodesia via the Republic of South Africa. Chromite exports from South African ports are already at a maximum. In 1974 the port of Lourenco Marques proved unable to handle all the tonnage available to it. Since taking over administration of the rail and port facilities in 1974, the Republic of South Africa has directed some funds to Lourenco Marques for the improvement of port handling facilities. This situation gives rise to three questions that may restrict growth in the Republic of South Africa.

1. Is there the physical capacity to handle a doubling of chromium product exports by 1980?
2. Will consumers be willing to increase their dependence on the Republic of South Africa, given the current political situation, if other sources of chromite are available?
3. Will consumers be willing to increase their dependency on the Republic of South Africa for ferrochromium, again given the current political situation? If so, there would not be sufficient plant capacity, outside the Republic of South Africa, for the conversion of chromite to ferrochromium to meet the requirements of the major consuming nations. If a long-term disruption of ferrochromium supplies from the Republic of South Africa occurred, the difficulties would be increased by the need to construct ferrochromium plants, on top of the need to find other sources of chromium. Indeed, Japan has recently expressed reluctance to become more dependent on chromite from the Republic of South Africa because of delivery problems and, further, the Japanese ferroalloy industry has expressed concern over increased dependence on imports of ferrochromium from the Republic of South Africa.

In 1966 the United Nations placed an embargo on exports from Rhodesia. At that time Rhodesia was the largest supplier of metallurgical-grade chromite and, as a result, the sanctions significantly affected the pattern of world trade. The United States was probably most seriously affected because it relied in large part on metallurgical-grade chromite produced in Rhodesia by subsidiaries of United States-based companies. While the United States observed the embargo, its ferrochromium industry experienced little growth, with the bulk of the incremental needs being supplied by imports. In 1972, the United States' ban on the import

Table 4. Estimated production of chromic oxide (Cr_2O_3) in chrome ores and concentrates, 1973-75

Country	1973	1974	1975
	(million tons Cr_2O_3)		
Malagasy	0.04	0.07	0.06
Republic of South Africa	0.69	0.84	0.92
Rhodesia	0.24	0.28	0.29
India	0.11	0.10	0.09
Philippines	0.21	0.19	0.19
Albania	0.19	0.19	0.19
U.S.S.R.	0.87	0.89	0.94
Finland	0.06	0.07	0.14
Greece	0.01	0.01	0.01
Cyprus	0.01	0.01	0.01
Turkey	0.21	0.27	0.32
Iran	0.07	0.07	0.07
Brazil	0.02	0.03	0.03
Other	0.05	0.05	0.05
Total	2.78	3.07	3.31

Source: Various publications; estimates of Cr_2O_3 by the Mineral Development Sector, Department of Energy, Mines and Resources, Ottawa.

of Rhodesian chromite was lifted as a result of the passage by Congress of the Byrd Amendment. Since that time, pressure to end U.S. imports from Rhodesia has been increasing, to a point in 1975 when African leaders in Rhodesia threatened Union Carbide that if it did not stop importing chromite from its Rhodesian mines, it would face the total loss of supplies from any future African government in Rhodesia. In the United States a Congressional delegation presented a bill that would reimpose sanctions against Rhodesia. The bill was narrowly defeated in the House of Representatives in September 1975. It is likely that this will continue to be a sensitive political issue in the United States until an arrangement is reached providing for black majority rule in Rhodesia.

Elsewhere in Africa, Kenya granted a consortium of Japanese companies a licence to investigate evidences of chromite mineralization in West Pokot. No results were announced. In Malagasy, Compagnie Minière d'Andriamena, its sole chromite producer, was nationalized on January 1, 1975. The nationalization is not expected to have any influence on its present trade pattern; however, it may well affect any future exploration for chromite by foreign firms in Malagasy.

In its latest five year plan, the U.S.S.R. set a chromite production target of 2.3 million metric tons by 1980, an increase of only 10 per cent over present production levels. The anticipated level of exports is 60 per cent of production, approximately the same as in 1975. At the present time some 80 per cent of exports go to noncommunist countries. No targets for the export mix to communist and noncommunist countries were announced. Past 1980, the U.S.S.R. is expected to increase chromite production significantly with the completion of its first underground chromite mine at Donskoye. Annual design capacity is 2 million metric tons a year of crude ore. Discussions continued during the year with ferroalloy producers in Japan, Europe and the United States on the construction of ferrochromium plants within the U.S.S.R. For any technical services rendered, the U.S.S.R. would prefer to pay in terms of product from the plant concerned.

In 1970, Etibank, Turkey's state-owned mining company, signed a contract with Japan Metals and Chemical Corporation (JMC) to deliver one million tons of chrome ore over a ten-year period. As part of the contract JMC supplied Etibank with two electric furnaces capable of producing high-carbon ferrochrome at the rate of 25,000 tons a year. Only a small part of this contract has been accepted but, with the opening of the Suez Canal in June 1975 and the uncertain situation for chromite, increasing amounts of this contract will be taken in the next several years. Etibank started up its Kef chromite project near Diyarbakir in eastern Turkey at the end of 1975. The project will produce about 135,000 tons of chrome concentrates a year, half of which is to be exported and half of which will go to a new ferrochrome plant near Elazig

Table 5. Composition and power consumption rates for chromium ferroalloys

Ferroalloy	Chromium	Carbon	Silicon	Power Consumption Rates
	(%)	(%)	(%)	(kwh/ton)
Charge chrome	52-58	6-8	. .	4,050[1]
HC Ferrochromium	66-77	4-6	1-2	4,500[2]
LC Ferrochromium	65-70	< 0.06	< 1.5	8,000[2]
Ferrochromium-silicon	33-36	< 0.05	45-48	8,600[2]

[1]From *Metal Bulletin Monthly, February 1974.* [2]*From Metal Bulletin*, June 7, 1974.
. . Not available.

scheduled to begin production in 1976. Technical assistance in the construction of the ferrochrome plant, which will produce about 55,000 tons a year, is being supplied by the Japanese company, Mitsubishi Corporation. As part of its policy of diversifying sources of raw materials, Japanese consumers have also formed a company, the Japanese Overseas Development Company, to explore for and develop Turkish chromite deposits.

The Greek Ministry of Industry has asked the National Institute for Geological and Mineral Research to prospect for new chromite reserves. The target areas are Verria, near Kozani; and at the foot of Mount Olympus. It is hoped to step up the output of the country's two existing mines to 50,000 metric tons a year from the present level of 30,000 metric tons. The increased production would be exported.

Exports of chromite were banned by the Indian Government because of the depressed state of the market for metallurgical ore. It was expected that the ban would soon be lifted and that a ceiling of, possibly, 30,000 metric tons for export would be imposed to safeguard the increasing local consumption.

Société de la Tiébaghi, a French subsidiary of Inco, has reached agreement with Compagnie Minière Dong-Trieu and two subsidiaries of Compagnie Financière de Paris et des Pays-Bas Group on the terms under which an exploration program and feasibility study will be conducted to determine whether a long-closed chromite mine at Tiébaghi in New Caledonia can be reopened on an economic basis. The mine, which ceased production in 1962, is owned by Société de la Tiébaghi. The exploration and feasibility program, managed by Société de la Tiébaghi, is scheduled to start in 1976 and is expected to take some two years to complete.

In December 1975, it was announced that a Philippine chromite producer, Perlite Minerals, hoped to receive a contract from Hungary for delivery of chromite starting early in 1976. The company began mining in August 1975 from a small deposit near Davau. Reserves are estimated to be 300,000 metric tons of ore.

Companhia de Mineraçao Serra da Jacobine (Serjana), a Brazilian-Japanese joint venture, is scheduled to begin production from a deposit in the Limoeria area of Brazil in 1976. Design capacity is some 120,000 metric tons a year of concentrate. Initially, all shipments will go to Japan.

Stockpiles

The only major stockpile is that held by the United States government. At the end of 1975 stocks were: 1,953,000 tons of metallurgical-grade chromite 250, 000 tons of chemical-grade chromite, 400,000 tons of refractory-grade chromite and 757,000 tons of chromium ferroalloys. Despite the fact that all stocks are well in excess of current objectives, no releases have been made recently and there has been no Congressional authorization to dispose of the excess. It is expected that the objectives will be revised upwards in 1976 as part of a general reconsideration of government stockpiling practices in the United States.

Use and technology

Metallurgical grade chromite is used primarily in the production of ferroalloys. Some metallurgical grade chromite is used in the production of chromium metal. The principal ferroalloys produced are high-carbon (HC) ferrochromium, low-carbon (LC) ferrochromium and ferrochromium-silicon.

As a constituent of iron castings, steels and superalloys, chromium increases resistance to oxidation and corrosion and the ability to withstand stress at high temperatures. In addition, chromium helps to refine the grain structure in iron castings.

The principal use of chromium ferroalloys is in the production of stainless and heat-resisting steels. Most applications of stainless and heat-resisting steels are in corrosive environments, e.g., petro-chemical processing; high-temperature environments, e.g., turbines and furnace parts; and consumer goods areas e.g., cutlery and decorative trim. Chromium is added to alloy and tools steels to increase hardenability and to improve some mechanical properties such as yield strength. Superalloys containing chromium have a high degree of resistance to oxidation and corrosion at elevated temperatures and are used in jet engines, gas turbines and chemical processing. Chromium-containing castings are usually used for high-temperature applications.

The development of the argon-oxygen decarburization (AOD) step in the manufacture of stainless and heat-resisting steels has prompted major changes in chromium usage. The AOD process, which was developed by Union Carbide Corporation and Joslyn Stainless Steels Division of Joslyn Mfg. & Supply Co., is essentially a refining step after the charge has been melted down. Argon, an inert gas, is used along with oxygen so that carbon instead of chromium will be preferentially oxidized. Among other benefits, this serves to increase the recovery of chromium in the steels.

The ability to use charge chrome, which requires less energy to produce than the other chromium ferroalloys, and the reduction in the total amount of ferroalloys required, should lead to a quick adoption of technologies similar to the AOD step. The overall advantages obtained are lower cost of chromium additions, and in major stainless steel-producing countries where electricity is expensive or in short supply, some savings in energy consumption for the production of ferroalloys. Another process, similar to AOD refining, is the Creusot-Loire-Uddleholm (CLU) process which is being developed commercially by some European steelmakers.

In effect, this means that the growth rate of chromium usage will be less than that of stainless steel

Table 6. Comparison of chromium consumption in an 18-8 stainless steel between AOD and pre-AOD steelmaking methods

	Pre-AOD		AOD	
	Gross Weight	Chromium Content[e]	Gross Weight	Chromium Content[e]
	(1 lb of alloy/ton of steel)			
Addition agent				
HC Ferrochromium[1]	114	79	209	115
LC Ferrochromium	73	46	9	6
Ferrochromium silicon	149	51	29	10
Total	336	176	247	131

Source: *Metals Week*, February 25, 1974.
[1] Average grade: pre-AOD 69-70 per cent Cr and AOD 52-58 per cent Cr (charge chrome).
[e] Estimated.

because of the more efficient use of chromium additions.

The refractory industry uses chromium in the form of chromite, principally in the manufacture of refractory bricks. Some chromite is employed for refractory purposes in mortars and in ramming, castable and gunning mixes, or directly for furnace repair.

Refractories composed of both chromite and magnesite are used principally in applications where basic slags and dust are encountered. The principal areas of use are in the ferrous and nonferrous metal industries. In the ferrous industry, chrome-magnesite brick is used in the basic open hearth and basic electric furnaces. The declining importance of the basic open hearth in steelmaking had led to a decline in the amount of chromite used as a refractory in the steel industry. The continuing decline in open-hearth production will be partially compensated for by the increase in electric furnace production and a slower decline or, possibly, a stabilization of chromite refractory consumption in the steel industry should result in the next few years. In the nonferrous industry, chrome-magnesite brick finds its principal use in converters. If oxygen-blowing in converters becomes economically feasible, the higher operating temperatures generated may necessitate a change to a higher-magnesite-content brick and thereby decrease chromite refractory usage.

The glass industry uses some chrome-magnesite brick in the reheating chambers of glass furnaces, and the kraft paper industry uses a dense chromite brick in recovery furnaces to resist chemical attack by spent liquors.

Chromite mortars and gunning mixes are used in the bonding and coating of basic bricks, or in areas where separation of various types of bricks by a chemically neutral substance is desirable. Castables and ramming mixes find their chief use in the open-hearth furnace.

Chromium chemicals have a wide variety of uses in a number of industries. Most chromium chemicals are derived from sodium dichromate, which is manufactured directly from chemical-grade chromite. The principal uses of chromium compounds are: in pigments, as mordants and dyes in the textile industry; as a tanning agent for all types of leathers; and in chrome electroplating, anodizing and dipping of various products. Among other uses, chromium compounds are used as oxidants and catalysts in the manufacture of various products such as saccharin; in the bleaching and purification of oils, fats and chemicals; and as an agent to promote the water insolubility of various products such as glues, inks and gels.

Prices

Despite weakening demand, U.S. published prices for chromite rose during 1975. The principal reason for the price rise in the United States was the threatened repeal of the Byrd Amendment. If it had been repealed, the United States would not have been able to import ferrochromium or chromite from Rhodesia under the UN sanctions. United States' consumers would then have had to make up this tonnage by buying from other producers. Therefore prices, particularly those for contract tonnages, reflected this tightening of supply that would have occurred had the Byrd Amendment been repealed. European chromite prices showed approximately equal increases during the year. At year-end, Russian chromite (min. 48% Cr_2O_3, Cr: Fe = 4:1, fob Russian port) was quoted at $150 a metric ton in New York and $150-$170 a metric ton in London; Turkish chromite (48% Cr_2O_3, Cr: Fe = 3:1, fob Turkish port) was quoted at $132-$142 a metric ton in New York and $130-$140 a metric ton in London; and South African chromite (44% Cr_2O_3, Cr: Fe = 3:1, fob Lourenco Marques) was quoted at $37-$52 a long ton in New York and $55-$65 a metric ton in London.

The weakness of the market showed more in the ferrochromium market where U.S. producer prices remained stable following a decline in the first quarter of 1975 despite rising chromite prices. Prices of imported ferrochromium declined throughout the year.

Outlook

The outlook for chromium is clouded by the uncertainty regarding the political situation in southern Africa. While there are ample reserves of chromite in the world, they are concentrated in the Republic of South Africa and Rhodesia. Any disruption of these supplies will create shortages and, if the disruptions were long-term, would create severe problems for the ferrochromium and stainless steel industries of most countries.

In the short-term, the flow of chromite from Rhodesia is the most important factor. When sanctions were imposed against Rhodesia in 1966, chromite prices rose and did not drop until passage of the Byrd Amendment in the United States in 1972. Access to Rhodesian chromite is an important factor in moderating prices for chromite. In 1975, the possibility that the United States would re-impose sanctions against Rhodesia was enough to cause a substantial price increase in a declining market. Recent developments, particularly the closure of the Rhodesian-Moçambique border, will limit the amount of Rhodesian chromite entering world markets. As demand improves, prices will rise unless there is a peaceful resolution of the Rhodesian problem.

In the mid-term the small increase in production planned by the U.S.S.R., handling problems at Lourenco Marques and a possible continuation of the political difficulties will lead to an under-supply of chromite. Prices for chromite can be expected to remain at their present levels, or increase, through 1980.

In the longer-term, the most important factor is how the Republic of South Africa reacts to the political pressures now being brought to bear on Rhodesia. The Republic of South Africa has the same problem as Rhodesia insofar as shipping of chromite is concerned. Because of its dominating position in chromite, the long-term stability of the chromite market is dependent on developments in the Republic of South Africa.

At the present time chromium will be an active commodity. Efforts to diversify supplies, such as those undertaken by Japan, will stimulate exploration for, and development of, chromite deposits in all parts of the world.

Prices

Chrome prices published by Metals Week

	December 13 1974	December 26 1975
	(U.S. $)	
Chrome ore per long ton, dry basis, fob cars Atlantic ports		
Transvaal 44% Cr_2O_3, no ratio	47-5	37-52
Turkish 48% Cr_2O_3, 3:1 ratio	65	132-142
Russian 54-56% Cr_2O_3, 4:1 ratio per metric ton in 1971	53-58	150
Chromium metal		
Electrolytic, 99.8% fob shipping point, per lb	2.45	2.44
	(U.S. ¢)	
Ferrochrome per lb Cr content, fob shipping point		
High carbon 67-70% Cr, 5-6% C	54.0	54.0-61.0
Imported charge chrome	65.0-75.0	44.0-50.0
Low carbon 67-73% Cr, 0.025% C	—	—
E.M.J. Price differences		
Chromium metal-electrolytic	2.8	2.44
Ferrochrome		
High carbon eff. 12-28-74	46.0¢	54-61
Low carbon eff. 1-30-75	1.0¢	92-120

Tariffs

Canada

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
		(%)	(%)	(%)	(%)
32900-1	Chrome ore	free	free	free	free
34700-1	Chromium metal, in lumps, powder, ingots, blocks or bars and scrap alloy metal containing chromium for use in alloying purposes	free	free	free	free
37506-1	Ferrochrome	free	5	5	free
92821-1	Chromium oxides and hydroxides	10	15	25	10
	from July 15, 1971 to Feb. 28, 1976 with the exception of the following:				
	Chromic oxides	free	free	free	free
	Chromium trioxide	free	free	free	free
92838-8	Chromium potassium sulphate	free	free	10	free
92838-9	Chromium sulphate, basic	free	free	10	free

United States

Item No.		1975
		(%)
601.15	Chrome ore	free
632.18	Chromium metal, unwrought (duty on waste and scrap suspended)	5
632,84	Chromium alloys, unwrought Ferrochromium	9
607.30	Not containing over 3% by weight of carbon	4
607.31	Containing over 3% by weight of carbon	0.625¢ per lb on chromium content
531.21	Chrome refractories	12.5
473.10	Chrome colours	5
420.98	Chromate and dichromate	0.87¢ per lb.

Sources: For Canada, the Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa. For United States, Tariff Schedules of the United States Annotated 1976, TC Publication 749.

Clays and Clay Products

G.O. VAGT

Clays are natural, earthy, fine-grained mineral materials, composed mainly of a group of hydrous aluminum silicates and which may contain iron, alkalis and alkaline earths. The clay minerals, formed by the chemical weathering or alteration of aluminous minerals such as feldspar and mica, are generally classified into three major groups based on detailed chemistry and crystalline structure; the kaolinite group, the montmorillonite group and the illite group. Clay deposits suitable for the manufacture of ceramic products may include nonclay minerals such as quartz, calcite, dolomite, feldspar, gypsum, mica, iron-bearing minerals and organic matter. The nonclay minerals may, or may not, be deleterious, depending upon individual amounts present and on the particular application for which the clay is intended.

The commercial value of clays, and of shales that are similar in composition to clays, depends mainly on their physical properties; plasticity, strength, shrinkage, vitrification range and refractoriness, fired colour, porosity and absorption, as well as on the proximity of any given deposit to growth centres in which clay products will be consumed.

Uses, type and location of Canadian deposits

Common clays and shale. Common clays and shales are the principal raw materials available from Canadian deposits for the manufacture of clay products. These materials are usually higher in alkalis, alkaline materials and iron-bearing minerals and much lower in alumina than the high-quality kaolins, fire clays, ball clays and stoneware clays. Common clays and shales are found in all parts of Canada, but deposits having excellent drying and firing properties are generally scarce and new deposits are continually being sought.

The clay minerals in common clays and shales are chiefly illitic or chloritic. Their fusion points are low, usually well below pyrometric cone equivalent* number 15 (PCE 15), which is defined by a temperature of approximately 1,430°C and is considered to be the lower limit of the softening point for fire clays. The presence of iron usually results in a salmon or red fired colour.

Suitable common clays and shales are utilized in the manufacture of heavy clay products such as common brick, facing brick, structural tile, partition tile, conduit tile, quarry tile and drain tile. Some Canadian common clays are mixed with stoneware clay for the manufacture of facing brick, sewer pipe, flue lining and related products. The raw materials utilized in the heavy clay industry usually contain up to 35 per cent quartz. If the quartz, together with other nonplastic materials, exceeds this percentage, the plasticity of the clay is reduced and the quality of the ware is lowered. If calcite or dolomite is present in sufficient quantities the clay will fire buff and the fire strength and density will be adversely affected.

Most of the surface deposits of common clays in Canada are the result of continental glaciation and subsequent stream transport. Such Pleistocene deposits are of interest to the ceramic industry and include stoneless marine and lake sediments, reworked glacial till, inter-glacial clays and floodplain clays. These deposits are characterized by low melting temperatures.

The common shales provide the best source of raw material for making brick. In particular, those found in Cambrian, Ordovician and Carboniferous rocks in eastern Canada, and Jurassic, Cretaceous and Tertiary rocks in western Canada, are utilized by the ceramic industry. In many instances these shales are more refractory than the Pleistocene clays.

China clay (kaolin). China clay is a high-quality white, or nearly white, clay formed from the decomposition of the mineral feldspar, a major constituent of granite. The natural decomposition process known as kaolinization, results in a hydrated aluminum silicate ($Al_2O_3.2SiO_2.2H_2O$) with the approximate percentage composition: 40 per cent Al_2O_3, 46 per cent SiO_2 and 14 per cent H_2O.

*The pyrometric cones are a convenient method of relating temperature and time by a single value.

None of the crude kaolins known to exist in Canada have been developed, primarily because of beneficiation problems and the small size of some deposits. Most occurrences contain a high proportion of quartz particles of varied sizes; mica, feldspar, magnetite, pyrite and colloidal iron have been noted as well. In the crude material the percentage of kaolinite frequently is small, making removal of impurities difficult.

China clay is used primarily as a filler and coater in the paper industry, a raw material in ceramic products, and a filler in rubber and other products. The following properties are required in clays used by the paper industry: low-viscosity characteristics when in clay-water systems, intense whiteness, high coating retention and freedom from abrasive grit. In the ceramic industry china clay is used as a refractory raw material. In prepared whiteware bodies such as wall tile, sanitaryware, dinnerware, pottery and electrical porcelain, quantities of nepheline syenite, silica, feldspar and talc are used as well.

Lower-quality kaolins in North America might be mined, and more expensive processing might be justified, as higher-quality deposits become depleted. If this situation arises, the development of a few Canadian deposits could become more attractive, particularly if new processing techniques and equipment become available.

Table 1. Canada, production of clay and clay products from domestic sources, 1973-75

	1973	1974	1975[p]
		($000)	
Production from domestic sources, by provinces			
Newfoundland	260	350	300
Nova Scotia	2,101	2,763	3,155
New Brunswick	840	1,048	1,310
Quebec	9,725	12,214	12,507
Ontario	34,601	39,074	38,363
Manitoba	1,257	778	676
Saskatchewan	2,014	2,406	2,672
Alberta	4,782	6,177	7,299
British Columbia	5,590	5,811	3,674
Total Canada	61,170	70,621	69,956
Production[1] from domestic sources, by products			
Clay-fire clay and other clay	775	832	824
Firebricks and fire clay blocks and shapes	1,338	1,438	1,424
Brick-soft mud process	603	647	641
stiff mud process	32,096	36,718	36,372
dry press	9,387	8,255	8,177
fancy and ornamental sewer brick and paving brick	791	911	902
Structural hollow blocks	225	92	91
Drain tile	3,838	5,783	5,729
Sewer pipe	4,529	3,451	3,419
Flue linings	2,668	4,899	4,853
Pottery (glazed and unglazed including earthenware, sanitaryware, stoneware, flower pots, etc.)	4,920	7,595	7,524
Total	61,170	70,621	69,956

Source: Statistics Canada.
[1]Producers' shipments. Distribution for 1975 estimated by Statistics Section, Mineral Development Sector.
[p]Preliminary.

Table 2. Canada, imports and exports of clay, clay products and refractories, 1974-75

	1974		1975p	
	(short tons)	($000)	(short tons)	($000)
Imports				
Clays				
Bentonite	290,491	3,947	266,862	4,789
Drilling mud	22,090	3,876	15,952	5,324
China clay, ground or unground	199,805	7,418	163,559	6,783
Fire clay, ground or unground	49,230	1,594	47,752	1,861
Clays ground or unground	111,912	2,371	151,336	3,866
Clays and earth activated	89,988	3,631	48,359	4,511
Subtotal, clays	763,516	22,837	693,820	27,134
	(M)		(M)	
Clay products				
Brick-building, glazed	2,770	254	5,153	352
nes	39,220	2,726	39,507	3,278
Building blocks	. .	568	. .	690
Clay bricks, blocks and tiles, nes	. .	1,082	. .	2,365
Earthenware tile	(sq. ft.)		(sq. ft.)	
under 2½" x 2½"	26,337,246	9,447	15,931,686	5,870
over 2½" x 2½"	45,480,721	13,041	39,687,374	12,907
Subtotal, brick blocks, tile	. .	27,118	. .	25,462
Tableware, ceramic	. .	44,395	. .	49,671
Porcelain, insulating, fitting	. .	7,432	. .	9,589
Pottery settings and firing supplies		500	. .	580
Subtotal, porcelain pottery	. .	52,327	. .	59,840
	(short tons)		(short tons)	
Refractories				
Firebrick and similar shapes				
Alumina (47% and over)	62,844	12,031	46,295	11,449
Chrome (34% and over)	2,123	578	4,324	1,171
Magnesite (53% and over)	21,713	6,971	24,648	9,439
Silica (80% and over)	16,312	3,720	18,818	7,303
nes	220,677	21,813	158,972	22,858
Refractory cements and mortars	. .	4,353	. .	5,822
Acid-proof brick	. .	341	. .	235
Crude refractory material	7,582	647	6,467	996
Grog (refractory scrap)	21,491	1,013	16,382	1,006
Refractories, nes	. .	4,249	. .	4,821
Subtotal, refractories	. .	55,716	. .	65,100
Total clay, clay products and refractories	. .	157,998	. .	177,536

Table 2 (cont'd)

	1974		1975[p]	
	(short tons)	($000)	(short tons)	($000)
Imports (concl'd)				
By main countries				
United States	. .	81,423	. .	89,450
United Kingdom	. .	32,071	. .	39,027
Japan	. .	19,216	. .	19,498
Italy	. .	7,326	. .	8,183
West Germany	. .	5,281	. .	6,315
Greece	. .	1,664	. .	2,515
Spain	. .	1,580	. .	1,760
France	. .	1,274	. .	1,377
Austria	. .	780	. .	1,266
Netherlands	. .	2,024	. .	1,038
Others	. .	5,359	. .	7,107
Total	. .	157,998	. .	177,536
Exports				
Clays, ground and unground	2,557	120	3,084	91
	(M)		(M)	
Clay products				
Building brick clay	11,780	1,600	7,227	1,322
Clay bricks, blocks, tiles nes	. .	530	. .	358
Subtotal, bricks, blocks, tiles	. .	2,130	. .	1,680
High-tension insulators and fittings	. .	1,909	. .	2,254
Tableware	. .	5,226	. .	3,246
Subtotal, porcelain, tableware	. .	7,135	. .	5,500
Refractories				
Firebrick and similar shapes	58,230	10,098	53,728	12,601
Crude refractory materials	1,185,607	1,769	591,068	1,707
Refractory nes	. .	2,020	. .	2,734
Subtotal, refractories	. .	13,887	. .	17,042
Total clays, clay products and refractories	. .	23,272	. .	24,313

Table 2 (concl'd)

	1974		1975^p	
	(short tons)	($000)	(short tons)	($000)
Refractories (cont'd)				
By main countries				
United States	. .	15,460	. .	15,157
Poland	. .	412	. .	1,101
Dominican Republic	. .	822	. .	854
South Africa	. .	475	. .	710
Chile	. .	624	. .	691
France	. .	459	. .	360
Mexico	. .	346	. .	351
Greece	. .	172	. .	337
Italy	. .	141	. .	301
Australia	. .	939	. .	283
West Germany	. .	82	. .	274
United Kingdom	. .	425	. .	231
Others	. .	2,915	. .	3,663
Total	. .	23,272	. .	24,313

Source: Statistics Canada.
^{p} Preliminary; . . Not available; nes Not elsewhere specified; (M) = 1,000.

In southern Saskatchewan, deposits of sandy kaolin occur near Wood Mountain, Fir Mountain, Knollys, Flintoft and other localities. Despite considerable work, no satisfactory method of producing a good commercial kaolin from these deposits has been developed.

A deposit of refractory clay which ranges from very plastic to very sandy, and is similar to a secondary china clay, occurs along the Fraser River near Prince George, British Columbia. This material has been investigated as a source of kaolin, as a fire clay and as a raw material for facing brick.

Various kaolinitic-rock deposits in Manitoba have been investigated. The reported deposits are principally in the northwest at Cross Lake and Pine River, on Deer Island (Punk Island) and Black Island in Lake Winnipeg, and at Arborg. Kaolinitic clays occur near Kergwenan and are being used for the manufacture of brick and tile.

Various companies have shown considerable interest in Quebec's kaolin-bearing deposits, although the deposits, in general, contain an excessive amount of quartz and iron minerals. Kaolin-bearing rock occurs at St-Remi-d'Amherst, Papineau County; Brébeuf, Terrebonne County; Point Comfort, on Thirty-one Mile Lake, Gatineau County; and Château-Richer, Montmorency County.

Extensive deposits of kaolin-sand mixtures occur in northern Ontario along the Missinaibi and Mattagami rivers. Algocen Mines Limited has found substantial quantities of kaolin-silica mixtures along the Missinaibi River north of Hearst. Results to date indicate that the kaolin has good refractory characteristics and meets specifications for filler-grade material. Potential uses for the silica, which comprises 80 per cent of the deposit, include glass manufacture, abrasive flour and ceramic application. The long distance from markets and the difficult terrain and climate of the area hinder development.

Ball clay. Ball clays are a very fine-grained, sedimentary kaolinitic type of clay with unfired colours ranging from white or various shades of grey, depending on the amount of carbonaceous material present.

Ball clays obtained in Canada are mineralogically similar to high-grade, plastic fire clay. They are composed principally of fine-particle kaolinite and quartz, with less alumina and more silica than kaolins. Ball clays are extremely refractory materials. In whitewares they impart a high green strength as well as plasticity to the bodies. Although white firing clays are most suitable, fired products which are cream coloured do not interfere with the quality of the whiteware products.

Ball clays are known to occur in the Whitemud Formation of southern Saskatchewan. Good-quality deposits are present at Willows, Readlyn, Big Muddy Valley, Blue Hills, Willow Bunch, Flintoft and other areas. Clay from the Willows area has been used for many years in the potteries at Medicine Hat, Alberta and Vancouver, British Columbia; however, the lack of proper quality control, the long distance from large markets and lack of reserves have been the principal disadvantages preventing the widespread use of this material. Some ball clays from the Flintoft area are used for white-to-buff facing brick and for household pottery and crocks.

Table 3. Canada, shipments of clay produced from imported clay[1], 1972-74

	1972		1973		1974p	
	(000 ft²)	($000)	(000 ft²)	($000)	(000 ft²)	($000)
Glazed floor and wall tile	17,641	6,958	19,861	8,678	22,020	10,193
Electrical porcelains	. .	17,273	. .	20,154	. .	26,260
Pottery, art and decorative ware	. .	644	. .	3,183	. .	2,629
Pottery, other	. .	2,753	. .	893	. .	169

Source: Statistics Canada.
[1]Does not include refractories; . . Not available.

Table 4. Canada, shipments of refractories, 1972-74

	1972		1973		1974p	
	(short tons)	($000)	(short tons)	($000)	(short tons)	($000)
Firebrick and similar shapes[1]	135,796	21,833	148,758	27,274	142,478	30,370
Cement, mortars, castables	88,031	13,435	93,159	14,651	82,047	14,978

Source: Statistics Canada.
[1]Includes fire clay blocks and shapes, firebrick, etc., made from domestic clays, and rigid firebrick, stove linings and other shapes made from imported clays, chrome ore, magnesite, etc. Silica brick not included.
pPreliminary.

Table 5. Canada, clay and clay products, production and trade, 1966-75

	Production					
	Domestic Clays[1]	Imported Clays[2]	Total	Refractory Shipments[3]	Imports[4]	Exports[4]
	(millions of dollars)					
1966	43.0	35.9	78.9	28.6	71.7	12.6
1967	44.3	35.5	79.8	30.7	70.7	13.7
1968	48.7	39.6	88.3	33.2	65.4	11.8
1969	49.5	34.5	84.0	35.5	76.3	14.0
1970	51.8	33.6	85.4	42.3	81.2	15.6
1971	50.2	35.1	85.3	39.8	84.5	15.5
1972	52.6	39.4	92.0	39.7	98.5	15.9
1973	61.2	49.9	111.1	47.0	115.5	23.7
1974	70.6	56.7	127.3	61.5	158.0	23.3
1975p	70.0	. .	. .	. .	177.5	24.3

Source: Statistics Canada.
[1]Production (shipments) of clay and clay products from domestic material. [2]Production (shipments) of clay products from imported clays. [3]Includes firebrick and similar shapes of all types, refractory cements, mortars, castables, plastics, etc., plus all other products shipped. [4]Includes refractories.
pPreliminary; . . Not available.

Fire clay. Fire clays contain high percentages of alumina and silica. They may be sedimentary or residual in origin, plastic or nonplastic, and are composed mainly of kaolinite. The classification of fire clays may be related to their composition, physical characteristics, refractoriness, use, or association with other minerals. Descriptive terminology includes plastic fire clay, nonplastic fire clay, high-alumina fire clay, or high-heat-duty fire clay. Fire clays are plastic when pulverized and wetted, rigid when subsequently dried, and of sufficient purity and refractoriness for use in commercial refractory products.

Canadian fire clays are used principally for the manufacture of medium- and high-duty firebrick and refractory specialties. High-duty refractories require raw materials having a PCE of about 31.5 to 32.5 (approximately 1,699° to 1,724°C). Intermediate-duty refractories require raw materials having a PCE of about 29 (approximately 1,659°C) or higher. Clays having a PCE of less than 29 but greater than 15 (approximately 1,430°C) may be suitable for low-duty refractories or ladle brick, as well as for other clay products. Known Canadian fire clays are not sufficiently refractory for the manufacture of super-duty refractories without the addition of some very refractory material such as alumina.

Various grades of good-quality fire clay occur in the Whitemud Formation in southern Saskatchewan.

Good-quality fire clays occur on Sumas Mountain in British Columbia. Some fire clay from the Sumas deposit is exported to the United States, and a small quantity is used at plants in Vancouver.

Fire clay and kaolin occur in the James Bay watershed of northern Ontario along the Missinaibi, Abitibi, Moose and Mattagami rivers. Considerable exploration has been carried out in some parts of these areas in recent years.

At Shubenacadie, Nova Scotia, some seams of clay are sufficiently refractory for medium-duty refractories. Research has indicated that these deposits may be suitable for production of ladle brick. Clay from Musquodoboit, Nova Scotia has been used by a few foundries in the Atlantic provinces, and the properties and extent of this clay were investigated by the Nova Scotia Department of Mines.

Ontario and Quebec have no producing domestic sources of clay. These provinces import most of their requirements from the United States.

Stoneware clay. Stone clays are similar to low-grade plastic clays and are characterized by good plasticity, a vitrification range between PCE 4 and 10, a long firing range and a fired colour from buff to grey. They range from commercially inferior material through semi-refractory to firebrick clays. They should have low fire shrinkage, enough plasticity and toughness for shaping, no lime- or iron-bearing concretions and very little coarse sand.

Stoneware clays are used extensively in the manufacture of sewer pipe, flue liners, facing brick, pottery, stoneware crocks and jugs, and chemical stoneware.

The principal source of stoneware clay in Canada is the Whitemud Formation in southern Saskatchewan and southeastern Alberta. The Eastend area in Saskatchewan was formerly the source of much of the clay used at Medicine Hat. Stoneware clay pits are presently located in the Alberta Cypress Hills, southeast of Medicine Hat; and at Avonlea, Saskatchewan. Stoneware clays occur on Sumas Mountain, near Abbotsford, British Columbia. These clays are used in the manufacture of sewer pipe, flue lining, facing brick and tile.

In Nova Scotia, stoneware clays occur at Shubenacadie and Musquodoboit. The Shubenacadie clays are used principally for the manufacture of buff facing brick. Other similar deposits occur at Swan River, Manitoba, where some buff brick has been manufactured, Kergwenan, Manitoba and in British Columbia at Chimney Creek Bridge, Williams Lake, Quesnel, and near the Alaska Highway at Coal River. Quebec and Ontario import stoneware clay from the United States for manufacture of facing brick and sewer pipe.

Canadian industry and developments

The value of clays and clay products produced from domestic sources in 1975 was nearly $70 million, slightly down from the final 1974 figure of $70.6 million. Operators List 6, Ceramic Plants in Canada,

Table 6. Distribution of production facilities for ceramic products in Canada, 1975.

	Number of Plants					
Ceramic Product	Atlantic Provinces	Quebec	Ontario	Prairie Provinces	British Columbia	Total
Abrasives	—	5	10	—	—	15
Brick and Tile	4	7	32	5	3	51
Clay Sewer Pipe	1	—	2	2	1	6
Glass	1	5	9	4	2	21
Porcelain and Pottery	—	11	26	4	5	46
Porcelain Enamel	2	4	20	1	—	26
Refractories	—	5	12	1	4	22
	8	28	111	17	15	187

Note: Some plants produce more than one group of products.
Source: Based on Operators List 6, Ceramic Plants in Canada (1975), Mineral Development Sector, Department of Energy, Mines and Resources, Ottawa.
— Nil.

Table 7. Canada, consumption (available data) of china clay, by industries, 1973-74

	1973r	1974
	(short tons)	
Ceramic products	12,249	14,747
Paint and varnish	6,284	5,843
Paper and paper products[1]	126,986	120,291
Rubber and linoleum	8,312	4,239
Other products[2]	24,907	28,840
Total	178,738	173,960

Source: Statistics Canada. Component breakdown by Statistics Section, Mineral Development Sector.
[1]Includes paper, paper products and paper pulp. [2]Includes miscellaneous chemicals, cleansers, detergents, soaps, medicinals and pharmaceuticals, and other miscellaneous products.
r Revised.

(1975) published by the Department of Energy, Mines and Resources, indicates that there were 185 operating plants. Some plants manufacture more than one ceramic product or group of ceramic products. The distribution of these production facilities in Canada is presented in Table 6.

The brick and tile manufacturing industry accounts for nearly 30 per cent of the ceramic plants in Canada. These plants manufacture clay products which include common brick, facing brick, structural tile, quarry tile and drain tile, primarily from local common clays and shales. In recent years, requirements for brick as a structural material in low- to medium-rise buildings have been emphasized. The use of an oversize "through the wall" (TTW) brick, which provides wall thickness, now provides a significant market for brick manufacturers.

Six plants manufacture sewer pipe from domestic common clay, shale and fire clay. Of the porcelain and pottery producers; sanitaryware plants, electrical porcelain plants, wall tile plants, dinnerware plants and the art potteries are the principal consumers of ceramic-grade china clay and ball clays. These raw materials are imported mainly from the United States and Great Britain. Some of the art potteries and one of the dinnerware plants imported unfinished ware and completed the manufacturing process by glazing or decorating.

Most of the refractory manufacturing plants utilize imported clay including ball clay, fire clay and kaolin, as the principal ingredients in many of their products. The nine abrasives plants utilized both domestic and imported raw materials. The distribution was approximately half and half, except for silicon carbide, which was supplied entirely from domestic sources, and petroleum coke, which was imported. Domestic and foreign sources of raw materials were used by Canadian glass plants. Those in Quebec and Ontario accounted for most of the imported silica sand used. Porcelain enamel was produced and utilized at 26 plants.

World review

In the United States the general economic recession resulted in reduced activity in all phases of the construction industry. As a result, clay production was down to $50.1 million in 1975 from $60.1 million in 1974. The reduction was almost evenly distributed among all types of clay, including bentonite and fullers earth.

The major uses for specific clays in the United States are as follows: *kaolin*, paper manufacture, refractories, rubber manufacture; *ball clay*, dinnerware, sanitaryware, floor and wall tile; *fire clay*, firebricks, foundry sands; *bentonite*, iron ore pelletizing, foundry sand bonding, drilling mud; *fuller's earth*, absorbents and fillers, insecticide carriers; *common clay*, construction material.

Demand for clays is expected to increase at annual rates of between two and five per cent through 1980. However, continued growth of the energy-intensive, clay-based industries could be severely impeded by persistent energy problems. Environmental problems and the need for planned land utilization must also be considered in any projection of future developments in the clay industry.

Clays were produced in 47 states at a total of 1,718 mines during 1975. Adequate reserves of high-quality clays of all types, together with possession of clay-processing technology, assure the United States of a continuing position as a major world supplier of clays.

The United States is the world's leading producer of kaolin, accounting for 5.3 million tons in 1975. World kaolin production was 17.7 million tons in 1974, the latest year for which figures are available. United States' production was 6.4 million tons and the United Kingdom and the U.S.S.R. followed with 3.9 million and 2.3 million tons, respectively. France, Czechoslovakia, West Germany and Spain are other leading producers. The United Kingdom is the world's leading exporter of kaolin, mainly to Europe, the United States and Japan. Paper manufacturing industries of West Germany, France and the Netherlands are the major users of these shipments.

Production of kaolin in Japan is on a very small scale, except at the Itaya Mine, Yamagata Prefecture, Honshu Island, which produces about 150,000 tons a year. Total kaolin output is about 430,000 tons a year, most of which goes into the manufacture of refractories, for which it is best suited. The United States is the principal source of imports, supplying over 200,000 metric tons of kaolin and nearly 150,000 tons of other clays. Lesser amounts of kaolin are imported from South Korea, Britain and the U.S.S.R.

Greece produces approximately 60,000 tons of kaolin annually, almost all for domestic consumption.

Denmark produces about 20,000 tons of kaolin a year. Most of the output is utilized in the manufacture of low-alumina refractories and glazed heavy-clay products. Requirements for paper and other uses are mainly imported from Britain, Czechoslovakia and West Germany.

The Netherlands does not produce kaolin, but acts as a very important distribution point for American and British clay entering Europe.

Outlook

Demand for clay and clay products, along with other construction materials, is expected to increase in 1976 in line with building construction expenditures in Canada which are forecast to increase by $2 billion to over $18 billion in 1976.

The weakened markets for kaolin in the United States are expected to turn upward following the 1975 recessionary period in the U.S. paper industry. Demand for kaolin products in paint, plastics, and ceramics is also expected to increase following the recessionary period. However, representatives of one major producer in the U.K. expect that consumption growth for paper-grade kaolin in western Europe will be less in the 1975-1980 period than in earlier periods. Projections suggest that growth rates will range from 2 per cent to 8.4 per cent, depending on grade. Economic growth in western Europe is expected to amount to about 3 per cent per annum, rather than 4.5 per cent as in the past. The bulk of new requirements to meet projected growth in demand for high quality kaolins is expected to come from expanded industries in the United States and Czechoslovakia. The Felipe kaolin deposits situated along the Jari River in Brazil are also expected to supply high-quality kaolins to meet world market requirements.

Kaolin, as well as other minerals such as perlite, gypsum, diatomite, and various clays, is being used in growing quantities as a carrier for pesticides.

Demand for high-grade, super-duty refractories continued to be high through 1975 as indicated by imports of both alumina and magnesite firebrick. Steel processes such as the basic oxygen furnace, pressure pouring and continuous casting, represent relatively new refractory requirements. New products and designs have also been dictated by changes in reducing atmospheres in the chemical and petro-chemical industry, by increased demand for high-purity glass and by the need for more economical production of ceramics.

The few known deposits of fire clays and ball clays in the developed areas of Canada are being utilized. Much assessment work has been done on deposits containing kaolin but, because of small size, high cost of beneficiation, or remoteness from transportation or industry, none has been developed. Ontario and Quebec are particularly deficient in developed deposits of refractory- or kaolin-type clays.

Clay and shale, like other low-cost construction materials, must be produced near the heavily populated areas where the markets are situated. This necessary feature of the industry will continue to produce increasingly complex problems related to rising land costs, land-use conflicts, environmental control requirements, and cost of land rehabilitation. The situation is particularly acute in southwestern Ontario where suitable reserves of brick-shales and other construction materials are being depleted, with few prospects for the opening of new pits and quarries under present controls. Some end-use products such as brick and tile find competition from cement, glass, metals and plastic manufacturers, but clays, being generally less expensive and very satisfactory for their intended uses, are usually able to hold their own, or to increase at the expense of the alternate materials, for many end-uses.

Bentonite and fuller's earth

Bentonite, a clay which consists primarily of montmorillonite, a hydrous aluminum silicate with weakly-attached cations of sodium and calcium, is reviewed in a separate section of the Canadian Minerals Yearbook, 1975.

Fuller's earth is primarily a calcium montmorillonite clay characterized by natural bleaching and absorbent properties; it is similar to nonswelling bentonite. The terminology is confusing, and bentonite and fuller's earth may not necessarily be separated in world trade and production statistics by country. Attapulgite, a magnesium-aluminum silicate, is a form of high-quality fuller's earth.

Prices

United States clay prices, according to Chemical Marketing Reporter, December 29, 1975

	($ per ton)
Ball clay	
Domestic, crushed, moisture-repellant, bulk car lots, fob Tennessee	8.00-11.25
Imported lump, bulk, fob Great Lakes ports	40.50
Imported, airfloated, bags, car lots, Atlantic ports	70.00
China clay (kaolin)	
Water washed, fully calcined, bulk car lots, fob Georgia	120.00-150.00
Dry-ground, airfloated, soft, fob Georgia	18.00

Tariffs

Canada

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
		(%)	(%)	(%)	(%)
29500-1	Clays, including fire clay, pipe clay not further manufactured than ground	free	free	free	free
29525-1	China clay	free	free	25	free
28100-1	Firebrick containing not less than 90 per cent silica; magnesite firebrick or chrome firebrick; other firebrick valued at not less than $100 per 1,000, rectangular shaped, not to exceed 125 cubic inches for use in kiln repair or other equipment of a manufacturing establishment,	free	free	free	free
28105-1	Firebrick, nop, of a class or kind not made in Canada, for use in construction or rapir of a furnace, kiln, etc.	free	free	15	free
28110-1	Firebrick, nop[1]	5	10	22½	5
28200-1	Building brick and paving brick	10	10	22½	6½
28205-1	Manufactures of clay or cement, nop	12½	12½	22½	8
28210-1	Saggars, hillers, bats and plate setters, when used in the manufacture of ceramic products	free	free	free	free
28300-1	Drain tiles, not glazed	free	17½	20	free
28400-1	Drain pipes, sewer pipes and earthenware fillings therefor; chimney linings or vents, chimney tops and inverted blocks, glazed or unglazed, nop	15	20	35	13
28405-1	Earthenware tiles, for roofing purposes	free	17½	35	free
28415-1	Earthenware tiles, nop	12½	20	35	12½
28500-1	Tiles or blocks of earthenware or of stone prepared for mosaic flooring	15	20	30	13
28600-1	Earthenware and stoneware, viz., demijohns, churns and crocks, nop	20	20	35	13
28700-1	All tableware of china, porcelain, semiporcelain or white granite, excluding earthenware articles (Nov. 19/74 to June 30/76)	free	15	35	free
28705-1	Articles of chinaware, for mounting by silverware manufacturers	12½	17½	22½	11½
28710-1	Undecorated tableware of china, porcelain, semi-porcelain for use in the manufacture of decorated tableware	free	10	35	free

Tariffs (concl'd)

Canada

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
		(%)	(%)	(%)	(%)
28800-1	Stoneware and Rockingham ware and earthenware, nop	17½	20	35	13
28805-1	Chemical stoneware	free	10	35	free
28810-1	Hand forms of porcelain for manufacture of rubber gloves	free	free	35	free
28900-1	Baths, bathtubs, basins, closets, closet seats and covers, closet tanks, lavatories, urinals, sinks and laundry tubs of earthenware, stone, or cement, clay or other material, nop (from Nov. 19/74 to June 30/76)	12½	15	35	12½

United States

		(¢ per long ton)
521.51	Fuller's earth, not beneficiated	25
521.41	China Clay or kaolin	33
521.54	Fuller's earth, wholly or partly beneficiated	50
521.81	Other clays, not beneficiated	free
521.84	Other clays, wholly or partly beneficiated	50
521.61	Bentonite	40
521.71	Common blue clay and other ball clays not beneficiated	42
521.74	Common blue clay and other ball clays, wholly or partly beneficiated	85
521.87	Clays artificially activated with acid or other material	0.05¢ per lb + 6%

Sources: The Customs Tariff and Amendments, Department of National Revenue, Ottawa. Tariff Schedules of the United States, Annotated (1976) T.C. Publication 749.

[1] Not otherwise provided for.

Note: In addition to the above tariffs various duties are in existence on manufactured clay products, viz., brick pottery, artware, etc.

Coal and Coke

MICHAEL K. McMULLEN

The Canadian coal industry experienced a very good year in 1975 as production increased and markets remained buoyant throughout most of the year. Most mines operated at capacity and were relatively free of labour difficulties that hampered production in some mines in 1974. Additional capacity came on stream during the year, notably in Nova Scotia where the Cape Breton Development Corporation (Devco) doubled production at its new Lingan mine and in western Canada where Fording Coal Limited, British Columbia and Forestburg Collieries Limited, Alberta increased production significantly.

Total coal production in 1975 was 27.8 million tons*, an increase of some 4.4 million tons or 19 per cent over 1974. Bituminous coal production accounted for the bulk of this increase, which at 3.4 million tons, raised total bituminous coal output to 17.4 million tons. Large tonnage increases in British Columbia and Alberta were the principal factors. Subbituminous coal output rose by 17 per cent to 6.6 million tons, while lignite production increased marginally from 3.8 million tons to 3.9 million tons. Exports, which increased by 1 million tons to 12.9 million tons in 1975, accounted for roughly 46 per cent of total production in Canada, but nearly three quarters of total bituminous coal production. Shipments to Japan amounted to nearly 11.9 million tons. Imports were up to 16.8 million tons as consumers rebuilt stocks run down by supplier problems and a coal miners' strike in the United States in 1974. Of the coal consumed in Canada, about 18.2 million tons were used to generate electricity in thermal power stations, and 8.2 million tons of coking coal were carbonized to make 5.8 million tons of coke. Lesser amounts of coal were consumed by industrial users, principally cement and pulp and paper manufacturers, and by commercial users.

The average value of all types of coal in Canada rose from $12.92 a ton in 1974 to $21.21 a ton in 1975, an increase of approximately 64 per cent. The largest increase was for bituminous coal which increased from $19.53 a ton to $31.68 a ton. This increase was due mainly to significantly higher prices paid for coking coal under long-term contract. The average value of production for subbituminous coal and lignite increased to $4.72 a ton and $2.37 a ton, or by 27 per cent and 10 per cent respectively. These increases mainly reflected higher costs of production since most subbituminous coal and lignite production is related to integrated mine-mouth power generation operations.

Internationally, during 1975 most industrialized countries experienced downturns in economic activity that affected the demand for both coking coal and thermal coal through reduced demand for steel and reduced industrial need for electric power. This became evident in Canada towards the latter part of the year. Prices increased during the early part of the year, reflecting both the tight-market conditions of 1974 and increased costs. By mid-1975, however, spot prices had fallen sharply as stocks of coal and coke were being built up, and by year-end the situation had not improved. Nevertheless, prices on long-term contracts and for top-quality coals remained firm.

The potential for new markets for Canadian coals remained high throughout much of the year, particularly for increased exports and for the movement of western Canadian coal into central Canada. However, uncertainties of government policies, mainly relating to coal mine development, royalties, infrastructure and future domestic requirements, were having a dampening effect on the expansion of the industry.

Foreign consumers continued to show interest in western Canadian coking coal deposits, with Japanese, West German, Dutch and Italian interests taking equity partnerships in potential producing properties in British Columbia. The beginning of major shipments to central Canada markets from the west appeared to be launched as Ontario Hydro signed a contract with Luscar Sterco Ltd. of Alberta for a long-term supply of steam coal from a new mine near Hinton. However, the project was being delayed pending Government of Alberta approval of the mine.

Studies to improve coal transportation to central Canada and for export were under way during 1975. Neptune Terminals Ltd., a subsidiary of Federal Indus-

* The short ton of 2,000 pounds is used throughout unless otherwise stated.

tries Ltd., began an evaluation program of the Prince Rupert, B.C. area as a suitable site for a new marine bulk terminal. Another subsidiary, Thunder Bay Terminals Ltd., was also prepared to start construction of a similar terminal at Thunder Bay, Ontario, but construction has been delayed until Ontario Hydro, expected to be the major customer, can be assured that it will have coal to move and can guarantee an appropriate annual throughput.

During 1975 it was announced that two more western Canada coal operators had become licensees of the hydraulic mining technology being marketed in Canada by Kaiser Resources Ltd. on behalf of itself and its partners, Mitsui Mining Co. Ltd. of Japan and v/o Licensintorg of the Soviet Union, Denison Mines Limited is assessing the potential for hydraulic mining at its Quintette property in northeastern British Columbia. Coleman Collieries Limited will be testing hydraulic mining at its Tent Mountain area in southwestern Alberta. Fording Coal Limited became a licensee in late 1974. Because of the nature of the coal seams in the mountain area and the success of Kaiser's hydraulic

Table 1. Canada, coal production[1] by types, provinces and territories, 1974-1975

	1974^r		1975^p	
	(short tons)	($)	(short tons)	($)
Bituminous				
Nova Scotia	1,410,043	24,524,000	1,825,639	46,974,000
New Brunswick	415,048	5,387,000	461,320	7,279,000
Alberta	3,651,288^r	90,156,000	4,516,207	165,248,000
British Columbia	8,532,319	153,567,000	10,560,346	330,655,000
Total	14,008,698	273,634,000	17,363,512	550,156,000
Subbituminous				
Alberta	5,594,869	20,875,000	6,568,076	31,001,000
Lignite				
Saskatchewan	3,842,140	8,317,000	3,911,645	9,282,000
All types, Canada total	23,445,707^r	302,826,000	27,843,233	590,439,000

Source: Statistics Canada.
[1]Production represents clean coal output, plus raw coal sales from the mine, where there is a preparation plant at the mine, plus raw coal shipments where there is no preparation plant at the mine.
^{p} Preliminary; ^{r} Revised.

Table 2. Canada, coal production, imports, exports and consumption, 1965-1975

	Production	Imports[1]	Exports	Domestic Consumption
1965	11,500,069	16,595,393	1,225,994	25,835,511
1966	11,179,873	16,436,755	1,228,820	25,290,069
1967	11,141,334	16,114,190	1,338,353	24,986,330
1968	10,989,007	17,046,745	1,447,012	27,317,782
1969	10,671,879	17,347,404	1,377,872	26,455,330
1970	16,604,164	18,863,779	4,391,572	29,512,533
1971	18,432,199	18,136,181	7,733,775	28,249,835
1972	20,709,316	19,264,890	8,513,403	28,393,096
1973	22,567,349	16,347,840	12,023,700	27,415,021
1974	23,445,707	13,647,846	11,876,419	27,386,605
1975^p	27,843,233	16,815,628	12,891,151	..

Source: Statistics Canada.
[1] Coal imports for consumption.
^{p}Preliminary; .. Not available.

mine, the hydraulic mining technique holds great promise of being widely used in this area.

During the year the governments of each of the three coal-producing provinces in western Canada; British Columbia, Alberta and Saskatchewan, continued studies relating to the development of new coal policies. New legislation is expected to be introduced in 1976 in all three provinces.

Outlook

Production of all types of coal in Canada in 1976 is expected to reach about 29.5 million tons, an increase of about six per cent over 1975. The bulk of the increase will be subbituminous production for power generation in Alberta and bituminous output in Nova Scotia. It is estimated that about 13 million tons will be exported, primarily to Japan, for metallurgical use. Imports are expected to be roughly the same as in 1975.

In the period from 1975 to 1980 the growth in coal production is expected to relate mainly to new coalfired power stations scheduled to come on stream in Alberta and Saskatchewan to burn subbituminous coal and lignite respectively. Major new coal projects presently under assessment, particularly for coking coal, are not expected to have a large impact on production until after 1980. New governmental coal policies, availability of skilled labour, capital requirements and improved transportation services will be major factors affecting future coal development. Coal production is expected to increase to approximately 40 million tons in 1980 and, under appropriate conditions, could be more than double that in 1985.

Production and mine developments

British Columbia. All provincial production comes from the southeastern part of the province. Although there are a number of coal basins in the region, two are prominent. The first is the Crowsnest coal basin to the west of the Crowsnest Pass where Kaiser Resources Ltd. operates. The second is the upper Elk River basin to the north of Fernie where Fording Coal Limited carries out production. These basins have large medium-to-low volatile bituminous coal resources, characterized by thick coal seams that occur within faulted and disturbed lower Cretaceous rocks. A smaller Corbin basin to the east of Fernie is where Byron Creek Collieries Limited carries out operations. South of Fernie a number of isolated deposits occur in the Flathead River area. Other coal basins are found elsewhere in the province, including the northeast in the Sukunka River — Peace River region where low-to-medium volatile bituminous coal occurs, and in the south-central area near Hat Creek where lignite is found.

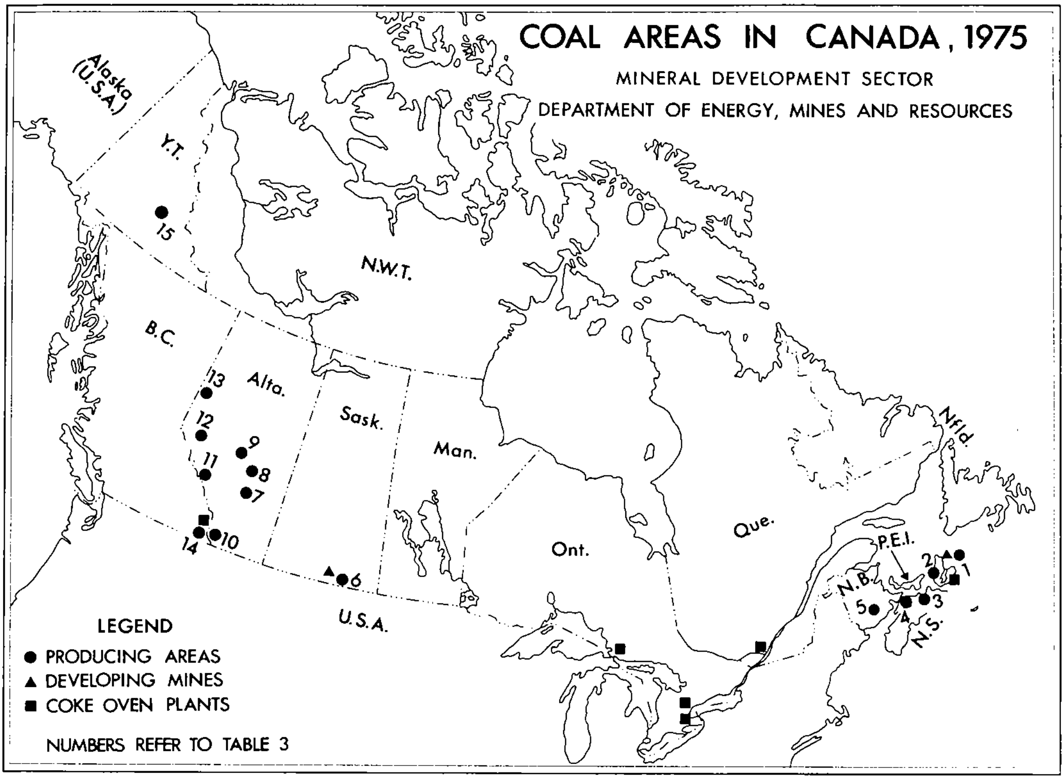
Kaiser Resources Ltd. produced about 6.2 million tons of clean coking coal from its Harmer Ridge surface mine and underground hydraulic and room-and-pillar mines located near Sparwood. In addition, 800,000 tons of oxidized coal were produced. The bulk of production, approximately 4.9 million long tons, was exported to Japan. This tonnage exceeded Kaiser's basic contract with the Japanese which called for 4.5 million long tons annually. Spot shipments of both coking coal and non-coking coal were made to other countries, and shipments of some 200,000 tons of coking coal were made to Dominion Foundries and Steel Limited (Dofasco) and The Steel Company of Canada, Limited (Stelco) in Hamilton.

As a result of a successful program undertaken in 1974-75 to expand the capacity of its surface mining operation, Kaiser agreed to increase its basic Japanese contract by 100,000 long tons to an annual total of 4.6 million tons to be effective in the 1975-76 contract year. Later in 1975 it was announced that this level would be increased to 4.75 million long tons annually, starting April 1, 1976. A new export contract was also negotiated during the year between Kaiser and Sumitomo Metal Industries Ltd. of Japan for 100,000 long tons a year of oxidized coal on a ten-year annual renewable basis beginning in late 1975.

Kaiser Coal Canada, Ltd., a joint venture company formed by Kaiser, Mitsubishi Corporation and Mitsui Mining Co. Ltd. of Japan, continued its feasibility study into the development of a new hydraulic mine in the Hosmer-Wheeler area about five miles south of Kaiser's present mining operations. This program is expected to be completed during 1976.

Fording Coal Limited produced coking coal from a multi-seam surface operation some 35 miles north of Sparwood near Elkford in the Fording River valley. Additional equipment and modifications to its overall mining plan enabled Fording to increase output from about 2.2 million tons in 1974 to 3.2 million tons in 1975. Virtually all production was shipped to Japan under a long-term contract which calls for three million long tons annually. In an effort to improve its overall yield of clean coal the company began a major revision to its preparation plant in October, with completion scheduled for early 1977. Fording also began investigative work on the potential for a hydraulic mine in the highest seam of its Eagle Mountain property. Assessment of the project will continue during 1976.

Byron Creek Collieries Limited produced approximately 350,000 tons in 1975 from its surface mining operations in the Crowsnest Pass area near Corbin. Some 200,000 tons were shipped to Ontario Hydro and most of the balance was sent to Hudson Bay Mining and Smelting Co., Limited at Flin Flon, Manitoba. Towards the end of the year it was announced that Byron Creek had signed a 13-year contract to export non-coking coal to Sumitomo Metal Industries Ltd. of Japan. Initially, 100,000 long tons will be shipped in each of the first three years, with the tonnage to be increased to 250,000-300,000 long tons per year for the balance of the contract. The first shipment was sent before the end of 1975.



In addition to the projects of the producing companies, several other projects were in various stages of development in British Columbia during 1975. In the northeastern portion of the province, in the Peace River area, Brascan Resources Limited continued to conduct marketing studies and consider mining alternatives for its Sukunka coking coal property some 70 miles south of Chetwynd, held under option from Brameda Resources Limited. Brameda gave Brascan a one-year extension, from June 30, 1975, to its option to purchase a larger interest in the property in return for monthly payments. Nearby, Brameda and Teck Corporation Limited conducted investigative work on the Bull Moose property.

In the Pine Pass region, Pine Pass Development Ltd. carried out exploration on coal leases optioned from Pan Ocean Oil Ltd., Utah Mines Ltd., a subsidiary of Utah International Inc. continued with exploration and development work on its large Carbon Creek project near Williston Lake. Farther south in the Quintette area, Denison Mines Limited and its partners; Alco Standard Corporation, Mitsui Mining Co., Ltd. and Tokyo Boeki Ltd., through their joint venture company Quintette Coal Limited, continued investigations on their large coking coal property. Both surface and underground production are being contemplated. Final evaluation of the project is expected during 1976.

In the Crowsnest Pass region, Scurry-Rainbow Oil Limited and Elco Mining Limited began a new feasibility study on their Elk River multi-seam coking coal property. In mid-1975, Elco, a consortium of West German, Dutch and Italian steel interests, purchased the 50 per cent interest in this property formerly held by Emkay Canada Natural Resources Ltd. In the same region some development work was carried on by Crows Nest Industries Limited on its Line Creek coking coal property. In January 1976 it was announced that Crows Nest and Mitsui & Co. Ltd. of Japan had reached agreement whereby Mitsui would undertake a feasibility study on the Line Creek property for completion in 1977. If Mitsui elects to participate in the development at that time, a joint company will be formed, to be owned 51 per cent by Crows Nest and 49 per cent by Mitsui.

(text continued on page 140)

Table 3. Principal coal producers in 1975

Company and Mine Location	Estimated 1975 Raw Coal Production	Coal Rank	Chief Markets	Remarks
	(short tons)			
Nova Scotia				
1. Cape Breton Development Corporation (DEVCO)				
Lingan Mine, Lingan	1,107,000	Hvb A	Power generation	Underground
No. 26 Colliery, Glace Bay	461,000	Hvb A	Metallurgical, Industrial, Domestic	Underground
Princess Colliery, Sydney Mines	71,000	Hvb A	Power generation, Industrial, Residential	Underground
Bardswich and McNeil Pits, Point Aconi	181,000	Hvb A	Power generation	Surface
Prince Mine, Point Aconi	53,000	Hvb A	Power generation	Pre-production, underground mine development
2. Evans Coal Mines Limited, St. Rose	18,000	Hvb B	Power generation, Residential	Underground
3. Drummond Coal Company Limited, Drummond, Westville	17,000	Mvb & Hvb A	Power generation	Underground
3. Thorburn Mining Limited, Stellarton	34,000	Hvb	Power generation	Coal recovered from waste heaps
4. River Hebert Coal Company Limited, River Hebert	33,000	Hvb A	Power generation	Underground
New Brunswick				
5. N.B. Coal Limited, Minto, Chipman areas	502,000	Hvb A	Power generation, Paper mills	Surface, operates at 6 locations
Saskatchewan				
6. Manitoba and Saskatchewan Coal Company (Limited), Bienfait Mine, Bienfait	438,000	Lig A	Power generation, Industrial	Surface
Boundary Dam Mine, Estevan	1,623,000	Lig A	Power generation	Surface
6. Manalta Coal Ltd. Klimax Mine, Estevan	800,000	Lig A	Power generation, Industrial	Surface
6. Utility Coals Ltd. c/o Manalta Coal Ltd., Utility Mine, Estevan	1,052,000	Lig A	Power generation	Surface

Table 3. (cont'd)

Company and Mine Location	Estimated 1975 Raw Coal Production	Coal Rank	Chief Markets	Remarks
Alberta				
Subbituminous mines				
7. Century Coals Limited, Atlas Mine, East Coulee	37,000	Sub B	Domestic, Power generation	Underground
Manalta Coal Ltd. Roselyn Mine, Sheerness	246,000	Sub C	Power generation, Domestic	Surface
8. Manalta Coal Ltd., Vesta Mine, Halkirk	570,000	Sub C	Power generation, Domestic, Industrial	Surface
8. Forestburg Collieries Limited Diplomat Mine, Forestburg	1,105,000	Sub C	Power Generation, Domestic, Industrial	Surface
9. Manalta Coal Ltd., Whitewood Mine, Wabamun	2,508,000	Sub A & B	Power generation	Surface
Highvale Mine, Sundance	2,033,000	Sub B	Power generation	Surface
Bituminous mines				
10. Coleman Collieries Limited Vicary Creek Mine, Coleman	222,000	Mvb	Japan for coke-making	Underground
Tent Mountain Mine, Coleman	1,063,000	Mvb	Japan for coke-making	Surface
11. The Canmore Mines, Limited Canmore	181,000 26,000*	An & Lvb	Japan for coke-making	Underground and Surface
12. Cardinal River Coals Ltd. Cardinal River Mine, Luscar	2,222,000	Mvb	Japan for coke-making	Surface
13. McIntyre Mines Limited, Smoky River Mines, Grande Cache	2,037,000* 879,000	Lvb Lvb	Japan for coke-making	Surface and Underground
British Columbia				
14. Kaiser Resources Ltd. Michel Colliery, Natal	1,200,000	Mvb	Japan for coke-making	Underground (hydraulic mining, room-and-pillar)
Harmer Ridge, Sparwood	7,269,000	Mvb	Japan for coke-making	Surface
14. Fording Coal Limited Fording Mine, Fording Valley	4,800,000	Mvb	Japan for coke-making	Surface
Byron Creek Collieries Limited, Corbin	373,000	Mvb	Ontario for power generation, Japan for formed coke	Surface

Table 3. (concl'd)

Company and Mine Location	Estimated 1975 Raw Coal Production	Coal Rank	Chief Markets	Remarks
Yukon				
15. Cyprus Anvil Mining Corporation Tantalus Butte Coal Mine, Carmacks	17,000 9,600	Hvb B Hvb B	Anvil lead-zinc mine for heating and concentrate drying	Underground and Surface

Source: Data supplied to the Mineral Development Sector by companies.
An — Semi-anthracite; Lvb — Low volatile bituminous; Mvb — Medium volatile bituminous; sub — Subbituminous; Lig — Lignite; Hvb — High volatile bituminous.
* Surface production.

Table 4. Canada, raw coal production by rank, province, type of mining and average output per man day, 1975^p

	Production		Average output per man-day[1(e)]	
	Underground	Surface	Underground	Surface
	(short tons)			
Bituminous				
Nova Scotia	1,882,857	100,991	3.5	41.5
New Brunswick	—	461,320	—	8.5
Alberta	1,290,716	5,442,106	11.0	27.0
British Columbia	1,241,660	13,002,151	16.0	36.0
Subbituminous				
Alberta	47,021	6,521,055	11.0	117.5
Lignite				
Saskatchewan	—	3,911,645	—	89.0
Canada 1975^p	4,462,254	29,439,268	9.5	59.0
1974	4,007,419	23,205,817	11.5	51.5
Total, all mines				
1975^p	33,901,522		52.6	
1974	27,213,236		44.6	

Sources: Statistics Canada and Department of Energy, Mines and Resources.
1Mine production and related employment only, excludes preparation plant workers, executive administrative, sales and office employees. Man-day refers to approximately an eight-hour man-shift.
^{p} Preliminary; ^{e} Estimated; — Nil.

In the Flathead River valley north of the British Columbia-Montana border, Rio Algom Limited earned a 60 per cent interest in the Sage Creek coking coal project by completing its option agreement with Pan Ocean Oil Ltd. Feasibility studies for a three-million-ton surface mining development are expected to be completed during 1976.

British Columbia Hydro and Power Authority (B.C. Hydro) began a major program to assess the lignite holdings in the Hat Creek area near Ashcroft during 1975. A major lignite-fired power station development is being considered for this site for initial operation proposed for the mid-1980s.

Alberta. Most of Alberta's coal resources are bituminous and subbituminous, but coal of all types from lignite to anthracite occurs in the province. Bituminous coal, much of which is of good coking quality, is located in the foothills and mountain belts, whereas subbituminous coal is found in the Plains region. Alberta is Canada's leading coal-producing province and has the largest number of coal mines.

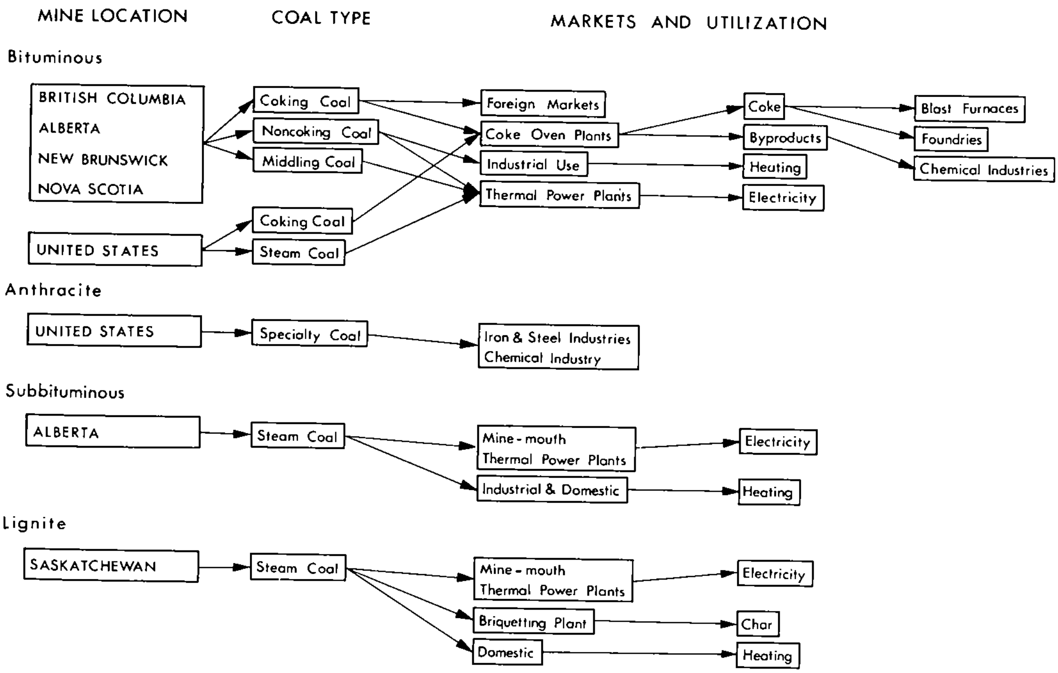
Four companies produced coking coal in Alberta during the year. At Grande Cache, McIntyre Mines Limited produced approximately 1.9 million tons of coking coal from one surface and one underground mine. The bulk of production came from the No. 9 surface mine which came into production in 1974. At the No. 2 underground mine, the No. 11 seam was brought into production during the year. Production from this seam will replace production from the No. 2 seam which will be exhausted in mid-1976. McIntyre shipped 1.5 million long tons of clean coal to Japan during the year under terms of a three-year contract that expires in 1978. In addition, the company shipped 200,000 tons to Stelco in Hamilton, Ontario, and 150,000 tons to the Sydney Steel Corporation (Sysco) in Sydney, Nova Scotia. For 1976, McIntyre has announced one-year contracts with Stelco for 100,000 tons, Dofasco for 50,000 tons and Sysco for 40,000 tons, beginning April 1, 1976.

Cardinal River Coals Limited produced 1.5 million tons of clean coking coal in 1975 at its Luscar mine, up from approximately 800,000 tons in 1974 when Cardinal experienced a five-month coal miners' strike. Cardinal's long-term contract with the Japanese calls for 1.5 million long tons annually. A trial shipment of coking coal was also sent to Dofasco in Hamilton.

In the Crowsnest Pass area of Alberta, Coleman Collieries Limited continued to operate its Vicary Creek underground mine as well as two open-pit mines at Tent Mountain. The present underground operation

COAL'S ROUTE TO CONSUMPTION

MINERAL DEVELOPMENT SECTOR
DEPARTMENT OF ENERGY, MINES AND RESOURCES



is to be phased out over the next three years. All the output of 850,000 tons of clean coking coal in 1975 was sold to the Japanese. Agreement was reached with the Japanese to supply an increasing tonnage in 1976 and 1977, to reach 900,000 tons in 1977. As a result of further extensive drilling and the driving of an adit, substantial reserves were proven up in the Tent Mountain area. The potential for hydraulic mining is to be determined on part of these reserves.

In 1975 The Canmore Mines, Limited of Canmore produced 185,000 tons of semi-anthracite coal, and exported some 169,000 tons to Japan under a long-term contract that expires in 1977. Although there are promising markets in Quebec for Canmore's semi-anthracite, recent rail freight rate increases make the possibility of achieving these markets difficult.

Exploration and development was restricted in Alberta during 1975 because of Alberta's moratorium on the development of new coal mines, although a large number of applications had been made to carry out work. In mid-year the moratorium was eased slightly as the Government of Alberta announced a multiple land-use program for the eastern slopes of the Rocky Mountains that also included the granting of eight permits to companies to carry out regulated stages of coal exploration and test work. These included two sampling permits, one to Luscar Sterco Ltd. to ship 40,000 tons of high-Btu steam coal to Ontario Hydro, and the other to Consolidation Coal Company of Canada to ship 17,000 tons of coking coal to a foreign customer. Companies granted exploration permits included Brascan Resources Limited and Shell Canada Limited, both in the Ram River area; Manalta Coal Ltd. at Gregg River, Luscar Ltd. at Coal Valley and McIntyre Mines near Grande Cache. No permits were granted for commercial projects. The new land-use policy envisages that 70 per cent of the eastern slopes will be left in their present undeveloped state.

In late September, Luscar Sterco Ltd. received Alberta Energy Resources Conservation Board (AERCB) approval to develop an open-pit bituminous steam coal mine at Coal Valley with a design capacity of 2.56 million tons of clean coal annually. The bulk of the output from the proposed mine is under contract to Ontario Hydro. However, approval is also required from the Alberta cabinet before the project can proceed. By year-end, approval for this project and Manalta Coal Ltd.'s Gregg River project, pending since 1974, had not been given. It has been indicated that no decisions on production permits will be made until the Government of Alberta announces its policy on coal, now expected in mid-1976.

In the plains region of Alberta, established sub-bituminous coal mines continued to be expanded; the main emphasis being on production for local power station use. The bulk of this coal is used at Calgary Power Ltd.'s Wabamun and Sundance power stations at Lake Wabamun, west of Edmonton, and at Alberta Power Limited's Battle River station in the Forestburg area.

In the Lake Wabamun area, Manalta Coal Ltd. produced approximately 2.5 million tons at Calgary Power's Whitewood mine and 2.0 million tons at Calgary Power's Highvale mine. With added capacity coming on line at the Sundance power station, coal production at the Highvale mine is expected to double in 1976. During 1975 Calgary Power received approval to add another 375-megawatt (mW) unit at Sundance. With completion of this unit in 1980 total station capacity will be 2,100 mW, which will require some seven to eight million tons of coal annually.

In the Forestburg-Halkirk region, Forestburg Collieries Limited and Manalta Coal Ltd. each operate surface mines that supply coal to Alberta Power's Battle River station. Coal requirements at Battle River will increase in 1976 with the first full year's operation of the 150-mW unit that came on stream in late 1975. A 375-mW addition is planned for the latter part of 1980. Manalta's Vesta mine produced 520,000 tons and Forestburg's Diplomat mine 1,125,000 tons. A portion of Forestburg's production in 1975 went to Stelco's new iron ore direct reduction operation in Northern Ontario that started up in mid-1975.

At Sheerness, Manalta Coal's Roselyn mine substantially increased production to some 246,000 tons as increased deliveries were made to the Saskatchewan Power Corporation's generating station at Saskatoon.

Saskatchewan. Coal production, all lignite, came from four surface mines in the Estevan-Bienfait region of southeastern Saskatchewan. Most production was sold to Saskatchewan Power Corporation (SPC) for use in its nearby power stations. The other important lignite market is in Manitoba where shipments are made to The Manitoba Hydro-Electric Board (Manitoba Hydro) for power station use. Smaller sales are made to industrial consumers both within and outside Saskatchewan as well as to local consumers. An additional market is indicated in Ontario where Ontario Hydro plans to use lignite from the Bienfait area to fuel its two 150 mW lignite fired units being built at Thunder Bay.

Lignite production in 1975 totalled about 3.9 million tons, up about 70,000 tons from 1974. At Estevan, the Manitoba and Saskatchewan Coal Company (Limited) produced some 1.6 million tons of lignite from its Boundary Dam mine and Utility Coals Ltd. produced about 1.1 million tons. Both mines are captive suppliers to the nearby Saskatchewan Power Corporation's Boundary Dam power station. With the addition of a 300-mW unit in 1977, coal requirements for the station will rise nearly 50 per cent to 4.5 million tons annually. The Klimax mine of Manalta Coal Ltd. produced 771,000 tons. At Bienfait the Bienfait Mine of Manitoba and Saskatchewan Coal Company (Limited) produced 430,000 tons.

A small surface mine located a few miles to the east of the Boundary Dam station will be brought into production by SPC in late 1976 to produce some 350,000 tons annually.

To the west of Estevan in the Willow Bunch area, a new coal mining centre will be established to provide lignite for a new lignite-fired power station to be built by SPC on the East Poplar River near Coronach. Initial requirements for the first unit of 300 mW will be approximately 1.5 million tons a year.

New Brunswick. The provincial Crown company, N.B. Coal Limited, which is the only producer of coal in New Brunswick, expanded output by about 11 per cent to 461,000 tons in 1975 from its surface mining operations in the Minto coalfield. Most of the high-volatile bituminous coal was sold to the New Brunswick Electric Power Commission for use in its Grand Lake power station; with most of the balance being sold to pulp and paper companies.

Since New Brunswick is presently dependent to a great extent on imported oil, renewed interest is being shown in the province's coal resources. During 1975, Lynx-Canada Explorations Limited and partners carried on a drilling program concentrated in the Beersville and Lake Stream areas in Kent County. A joint Government of Canada — Government of New Brunswick three-year coal inventory program is expected to get under way in 1976 to systematically evaluate coal resources in the province. The main market for any new reserves is expected to be power station use.

Nova Scotia. Nova Scotia's production of coal, which comes largely from the three underground mines of the Cape Breton Development Corporation (Devco) in the Sydney coalfield, increased to 1.8 million tons during 1975 from 1.4 million tons in 1974. This occurred even though Devco experienced a major underground fire at its No. 26 mine at Glace Bay that closed the mine for five weeks from mid-June to the latter part of July and affected production for the rest of the year. The section of the mine where the fire occurred was permanently sealed late in the year. Devco has accelerated development work at this mine and expects to add two longwalls, to bring the total to three longwalls. Full capacity of approximately 1.4 million tons annually is expected by late 1976. Devco also added a second longwall in its new mine at Lingan during 1975. Lingan is expected to reach an annual capacity of 1.8 million tons in early 1976 with the addition of a third longwall.

Table 5. Producers' disposition of Canadian coal[1], 1975

Destination	Originating Province					
	Nova Scotia	New Brunswick	Saskatchewan	Alberta	British Columbia and Yukon	Canada
	(short tons)					
Railways in Canada	38	—	70,242	40	—	70,320
Newfoundland	1,123	—	—	—	—	1,123
Prince Edward Island	12,968	—	—	—	—	12,968
Nova Scotia	1,132,514	4,777	—	81,925	—	1,219,216
New Brunswick	23,734	279,983	—	—	—	303,717
Quebec	81,212	156,306	—	1,517	—	239,035
Ontario	159,310	—	44,457	326,947	450,560	981,274
Manitoba	—	—	537,514	65,510	30,035	633,059
Saskatchewan	—	—	3,254,603	749,176	—	4,003,779
Alberta	—	—	—	5,905,279	—	5,905,279
British Columbia	—	—	—	17,137	328,854	345,991
Total Canada	1,410,899	441,066	3,906,816	7,147,531	809,449	13,715,761
United States	—	1,394	4,982	63,525	3,171	73,072
Japan	—	—	—	3,900,468	8,513,123	12,413,591
Other	377,078	—	—	39,436	529,244	945,758
Total Shipments	1,787,977	442,460	3,911,798	11,150,960	9,854,987	27,148,182

Source: Statistics Canada.
[1]Saleable coal (raw coal, clean coal and middling sales). — Nil.

Table 6. Canada, exports and imports of coal, 1974-75p

	1974		1975p	
	(short tons)	($)	(short tons)	($)
Exports				
Japan	10,993,226	229,880,000	11,865,998	455,001,000
United Kingdom	43,797	1,358,000	356,013	10,157,000
France	53,480	1,045,000	294,829	4,624,000
Denmark	109,039	1,653,000	150,521	2,519,000
Chile	25,760	357,000	–	–
Italy	53,698	1,193,000	–	–
United States	396,309	11,992,000	122,310	3,582,000
West Germany	165,484	3,584,000	100,962	1,989,000
South Korea	34,646	612,000	–	–
Ste. Pierre-Miquelon	980	33,000	518	28,000
Total	11,876,419	251,707,000	12,891,151	477,900,000
Imports (for consumption)				
Anthracite				
United Kingdom	–	–	3,580	192,000
United States	235,276	5,052,000	318,306	15,242,000
Total Anthracite	235,276	5,052,000	321,886	15,434,000
Bituminous				
France	–	–	3	3,000
Poland	–	–	33,690	1,997,000
United States	13,410,293	296,844,000	16,460,049	557,382,000
United Kingdom	2,277	110,000	–	–
Total Bituminous	13,412,570	296,954,000	16,493,742	559,382,000
Total Imports	13,647,846	302,006,000	16,815,628	574,816,000

Source: Statistics Canada.
p Preliminary; – Nil

Devco announced in early 1975 that it would develop a new underground room-and-pillar coal mine at Point Aconi. Production is expected to begin in late 1976 at a rated capacity of 600,000 tons annually. To be known as the Prince Mine, it will replace the Princess Colliery which is to be closed officially in 1976, after 100 years of production. With all this additional capacity available, Devco expects to produce about three million tons of coal from its mines in 1976.

Although Devco's main markets are in Nova Scotia for power generation and coke making, export shipments were made to the United Kingdom and other European countries in 1975. In addition, small shipments were made to Ontario Hydro. It was announced in November that a five-year contract had been signed with Stelco for delivery of 500,000 tons of coking coal annually. Deliveries will commence with operation of Devco's new preparation plant which is scheduled for completion in late 1976.

The Government of Canada – Government of Nova Scotia coal inventory program continued the drilling schedule that began in 1974. This three-year coal evaluation program will encompass most of the major coal bearing areas of the province, particularly in mainland Nova Scotia. Others active in coal exploration in 1975 included Cumberland Mining Associates in the Springhill area and Biron Bay Mines Ltd. at Mabou on Cape Breton Island.

Trade and markets

Exports. In 1975 exports of bituminous coal amounted to 12.9 million tons, an increase of 8.5 per cent from 11.9 million tons in 1974. The value of these exports increased sharply to $478 million from $252 million in 1974. Of total exports, about two-thirds originated from mines in British Columbia, with most of the balance from Alberta. Export shipments accounted for approximately 46 per cent of total coal production or nearly three-quarters of bituminous coal production. Japan received nearly 11.9 million tons, or 92 per cent of exports, compared to 11 million tons or 93 per cent in 1974. Since Canada's coal exports are mainly coking coal under long-term contracts, Canada's position in the international coal trade remained strong even though the international market softened noticeably during the latter part of 1975. In the early part of 1975, Canadian coal export producers and their Japanese buyers negotiated new coal prices on the basis of international pricing and abandoned the former vague basis of cost plus reasonable profit. The average value of Canadian coking coal exported to Japan in 1975 was in the order of $50.00 a long ton, fob Vancouver. This is approximately a 60 per cent increase over the 1974 price. Exports to countries other than Japan increased by some 142,000 tons to 1,025,000 tons. Of this total, shipments of thermal coals to the United Kingdom and France accounted for over 60 per cent.

If the soft market conditions for coal which were in evidence for the last half of 1975 continue into 1976, export levels of Canadian coals for 1976 can be expected to be lower than 1975. International price levels can also be expected to be subject to downward pressures.

Imports. Canada imported 16.8 million tons of coal in 1975, an increase of some 3.2 million tons from 1974, although shipments were down in August and September as a "wildcat" coal miners strike in West Virginia affected production at most mines. Larger imports were due mainly to rebuilding of stocks by Ontario Hydro and Ontario steelmakers to compensate for reduced deliveries in 1974. Bituminous coal accounted for 16.5 million tons, with the rest being anthracite. With the exception of small shipments from Poland, France and the United Kingdom all imports were from the Appalachian region of the eastern United States. About 8.2 million tons were imported for thermal power generation use in Ontario, with approximately 8.2 million tons imported for coke-making purposes. The balance of imports was used for heating and specialty markets. Imports for 1976 are expected to remain around the 1975 level.

Thermal power industry

The largest market for coal in Canada is for the generation of electricity. In 1975 consumption by electricity plants totalled 18.3 million tons up about 7 per cent from 17 million tons consumed in 1974. Approximately 10.8 million tons were domestic coals, mainly low rank coals consumed in western Canada, and the remainder was imported United States high-Btu coals for Ontario. At the end of 1975, total capacity of power stations in Canada having coal-fired capability stood at some 11,900 megawatts (mW). New coal-fired capacity under construction announced, or planned for installation by 1983, totals some 5,500 mW. In addition major expansion is planned for the 1983-1987 period, particularly in the coal-producing provinces of western Canada.

Table 7. Canada, supply and demand of coal, 1964 and 1974^p

	1964	1974^p
	(short tons)	
Supply		
Production	11,219,311	23,445,707
Landed imports	14,738,542	13,627,430
Total inventory change	−65,008	−2,189,887
Total supply	26,022,861	39,263,024
Demand		
Domestic sales		
Electric utilities	6,264,520	17,002,441
Mining and Manufacturing	7,407,873	1,575,109
Coke-making	6,023,035	8,297,279
Sub-total	19,695,428	26,874,829
Demand		
Residential	2,627,714	63,659
Railways	283,418	81,266
Ships bunkers	317,780	89,969
Government and institutional	203,000	55,400
Sub-total	3,431,912	290,294
Coal mine and local use	790,439	270,100
Unaccounted for coal	813,418	−48,618
Total domestic demand	24,731,197	27,386,605
Exports	1,291,664	11,876,419
Total demand	26,022,861	39,263,024

Source: Statistics Canada.
^{p} Preliminary

Ontario Hydro is the largest user of coal in Canada. In 1975, it burned some 7.5 million tons of bituminous coal, virtually all imported from the United States. A total of approximately 8.2 million tons were imported during the year. At present nearly all Ontario Hydro's coal demands are met by long-term supply contracts with coal companies in West Virginia and Pennsylvania. Consolidation Coal Company and Eastern Associated Coal Corp. are the two main suppliers to Ontario Hydro. During 1975 work continued on the Cumberland thermal coal mine project of United States Steel Corporation being developed in Pennsylvania to supply Ontario Hydro with 3 million tons annually over a 30-year period. Initial deliveries from the mine are scheduled for late 1977 with shipments of 3 million tons a year expected in 1980.

Expansion continued at Ontario Hydro's Nanticoke power station near Port Dover on Lake Erie as the fifth 500-mW unit came on line during the year. Unit No. 2 which was damaged by fire in mid-1974 came back into service in December. When completed in late 1977, Nanticoke will be the largest thermal power station in Canada, having a total capacity of 4,000 mW and consuming some 7.5 million tons of bituminous coal annually at a 60 per cent load factor. At Thunder Bay two lignite-fired 150-mW units are scheduled to be added in 1980-81 to the existing 128 mW coal-fired station. A new, four-unit, 800 mW coal-fired station is planned at Marmion Lake near Atikokan, scheduled for service in the 1983-87 period.

During 1975 Ontario Hydro announced that agreement had been reached with Luscar Sterco Ltd. to purchase high-volatile bituminous coal from a new mine to be developed at Coal Valley, Alberta. Deliveries will be dependent upon Luscar Sterco receiving a production permit for the mine.

In Alberta, Calgary Power Ltd. received approval in 1975 for the addition of another 375-mW unit to its Sundance power station located on the south shore of Lake Wabamun. This will be the fourth 375-mW unit and the sixth unit to be installed at Sundance. Units 3 and 4 both 375-mW, are scheduled to be in service during 1976. With completion of the last unit in 1980 total capacity of the Sundance station will be 2100 mW. As a base-load operation the station is expected to burn some 8 million tons of subbituminous coal annually from the nearby Highvale mine. This will make Sundance the largest single user of coal in Canada. Late in 1975, Calgary Power and Canpac Minerals Limited submitted applications to the AERCB for approval to build a coal-fired power station and develop an adjacent coal mine in the Camrose-Ryley area. Calgary Power plans to build a power station having six 375-mW units to come on line between 1982 and 1986 at a cost of $2.6 billion. Canpac proposes to develop a surface mine to supply a total of 300 million tons of subbituminous coal to the power station over a period of 35 years.

At Forestburg, Alberta Power Limited brought on line a 150 mW addition to its Battle River power station in December 1975. Total capacity is now 362 mW. A new 375 mW unit is scheduled for service in 1980-81. At Grande Cache, Alberta Power's H.R. Milner coal-fired station switched permanently during the year to burning coal byproducts from McIntyre Mines Ltd.'s preparation plant. The original plan to use coal middlings for the station has been abandoned.

In Saskatchewan, Saskatchewan Power Corporation (SPC) continued construction of a 300-mW unit at its Boundary Dam power station at Estevan to come on stream in 1977. Upon completion, total capacity of the station will be 882 mW which will require some 4.5 million tons of lignite annually. Saskatchewan Power is developing a 350,000 ton surface mining operation east of the station for production in late 1976 to complement the existing coal supply to the station.

In early 1975, SPC was given approval to construct a lignite-fired power station with an ultimate design capacity of 1,200 mW on the East Poplar River in the Coronach-Willow Bunch region of southern Saskatchewan. The first 300-mW unit is planned for service in mid-1979 and will burn some 1.5 million tons of lignite annually. A new lignite mining centre will be developed in the area to supply this station.

Manitoba Hydro maintains dual-fired power stations at Brandon and Selkirk. Use of these stations, which have a combined capacity of 393 mW, is dependent upon available hydro capacity. During 1975 approximately 350,000 tons of Saskatchewan lignite were burned.

In New Brunswick, the New Brunswick Electric Power Commission (NBEPC) operates its Grand Lake power station on high-volatile bituminous coal mined from the nearby Minto coalfield. NBEPC also operates a dual-fired station at Chatham which can burn coal but is now using only oil because of environmental concerns. At Dalhousie, a new 200-mW dual-fired unit to

Table 8. Provincial coal royalties in Canada

Province	Effective Date	Terms
Nova Scotia	1975	$0.25 a short ton
New Brunswick	1968	$0.14 a short ton
Saskatchewan	1957	$0.05 a short ton
Alberta	1948	$0.10 a short ton
British Columbia	1975	$1.50 a long ton, metallurgical grade $0.75 a long ton, thermal grade
Yukon and Northwest Territories	1965	lease: $0.10 a short ton
	1954	permit: $0.25 a short ton

Table 9. Principal coal-fired thermal power stations in Canada, 1975

Utilities	Station	Total Station Capacity (Kilowatts)	Remarks
Nova Scotia			
1. Nova Scotia Power Corporation	Glace Bay	111,000	
2. Nova Scotia Power Corporation	Trenton	210,000	
3. Nova Scotia Power Corporation	Harrison Lake	25,000	
New Brunswick			
4. New Brunswick Electric Power Commission	Chatham	32,500	
5. New Brunswick Electric Power Commission	Grand Lake No. 1	13,750	
New Brunswick Electric Power Commission	Grand Lake No. 2	85,000	
Ontario			
6. Ontario Hydro	Richard L. Hearn	1,222,500	
7. Ontario Hydro	Lakeview	2,422,500	
8. Ontario Hydro	Nanticoke	2,522,500	Three 500 mW units to be added by 1978.
9. Ontario Hydro	J. Clark Keith	271,500	To be shut down in 1976 for up to 30 months
10. Ontario Hydro	Lambton	2,022,500	
11. Ontario Hydro	Thunder Bay	128,300	Two 150 mW lignite fired units to be added by 1981.
Manitoba			
12. Manitoba Hydro	Selkirk	155,800	
13. Manitoba Hydro	Brandon	237,000	
Saskatchewan			
14. Saskatchewan Power Corporation	Estevan	70,000	
15. Saskatchewan Power Corporation	Boundary Dam	582,000	300 mW addition scheduled for 1977
16. Saskatchewan Power Corporation	Queen Elizabeth	232,000	
Alberta			
17. Alberta Power Limited	Drumheller	15,000	
18. Alberta Power Limited	Battle River	362,000	One 375 mW addition scheduled for 1980
19. Calgary Power Ltd.	Wabamun	582,000	
20. Calgary Power Ltd.	Sundance	600,000	Four 375 mW units to be added by 1981
21. Alberta Power Limited	H.R. Milner	150,000	Burns coal preparation plant by-products.

Source: Statistics Canada.

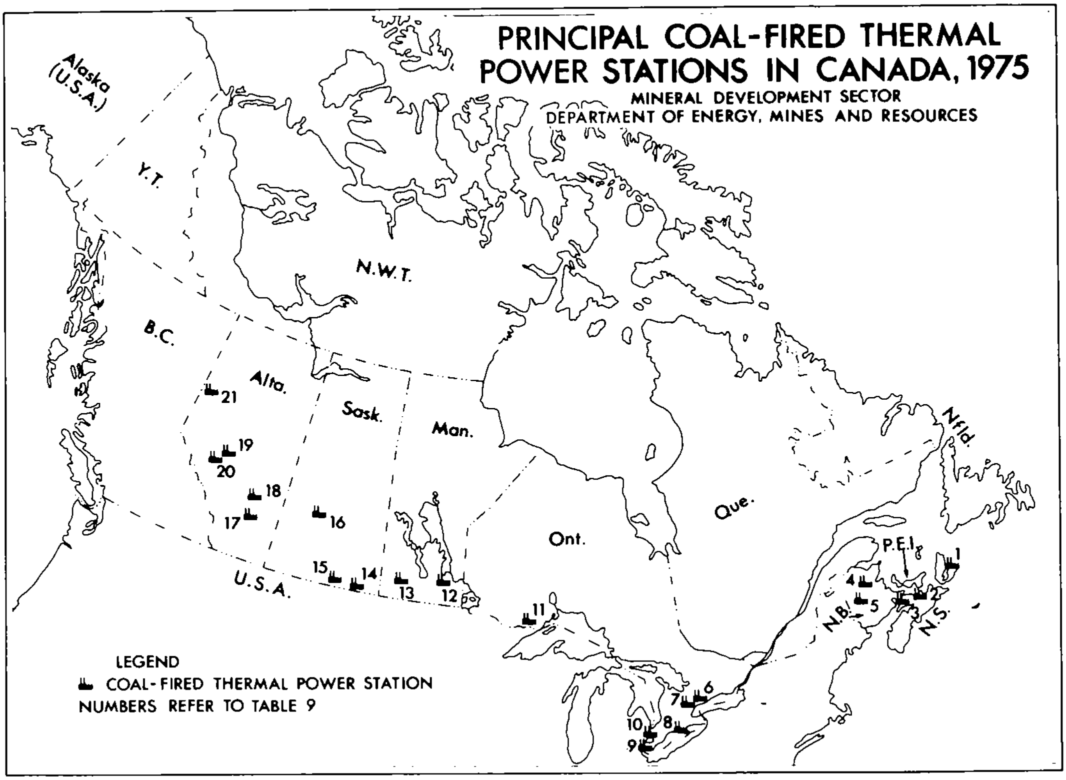


Table 10. Coal used by thermal power stations in Canada, by provinces, 1960-1975

	Nova Scotia	New Brunswick	Ontario	Manitoba	Saskat-chewan	Alberta	Total Canada
			(thousands of short tons)				
1960	494	202	118	56	770	206	1,846
1961	504	168	272	116	964	229	2,253
1962	515	121	1,493	111	1,129	356	3,725
1963	534	107	2,807	66	1,054	582	5,150
1964	584	245	3,081	145	1,109	1,101	6,265
1965	698	368	3,932	193	1,196	1,335	7,722
1966	881	324	3,858	87	1,230	1,499	7,879
1967	835	303	4,889	42	1,471	1,573	9,113
1968	712	264	6,088	197	1,492	2,346	11,099
1969	745	165	7,082	56	1,238	2,621	11,907
1970	604	125	8,483	555	2,170	3,253	15,190
1971	759	299	9,436	492	2,200	4,027	17,213
1972	731	310	8,376	452	2,364	4,534	16,767
1973	645	213	7,292	425	3,093	4,932	16,600
1974	668	322	7,409	145	3,199	5,259	17,002
1975p	629	273	7,533	356	3,584	5,892	18,267

Source: Statistics Canada.
p Preliminary; — Nil.

burn coal and oil is under construction and is scheduled for operation in 1978. On a base load basis this unit could burn some 300,000 tons of coal annually.

The Nova Scotia Power Corporation (NSPC) operates three thermal power stations in the province using high-volatile bituminous coals from Nova Scotia. The bulk of the coal comes from the mines of the Cape Breton Development Corporation on Cape Breton Island. During the year NSPC continued to evaluate the possibility of adding new coal-fired capacity to its system. The location and size of any such expansion would be mainly dependent upon adequate supplies of coal, sufficient for the service life of the station, being available. In January 1976 NSPC announced that a new coal-fired station would be built at Lingan on Cape Breton Island. Initially, a 150-mW unit would be built for operation in 1979. Ultimate capacity of the station could be 600 mW. A tentative supply agreement for this station has been made with Devco for approximately 400,000 tons of coal annually which would be sufficient to fuel the requirements of the first 150-mW unit.

Coke industry

Coking coal, when heated in the absence of air, produces coke, a dull grey, porous mass consisting largely of carbon. Coke is used mainly in the iron and steel industry, but also in other metallurgical processes. The production of coke is the second-largest market for coal in Canada.

In 1975, some 8.2 million tons of coking coal were carbonized to produce 5.8 million tons of coke. About 90 per cent of the coking coal used in Canada was imported from the United States. The three steel companies in Ontario operate coke oven plants in Hamilton and Sault Ste. Marie. All have captive United States mines and long-term contracts. In Sydney, Nova Scotia, the Sydney Steel Corporation (Sysco) uses a blend of Nova Scotia, western Canadian and imported coals to produce coke for its steel mill. The integrated steelmakers account for over 90 per cent of coke production in Canada.

Of the approximately 8.2 million tons of coking coal imported from the United States in 1975, approximately 4.5 million tons or some 55 per cent came from captive mines. Approximately 4.9 million tons, or 85 per cent of coke produced in Canada, was charged to blast furnaces for pig iron production. The remainder of the coke was used by foundries, chemical plants and nonferrous metal smelters. The market for coke byproducts such as gas, ammonia, tar and light oils is limited in Canada mainly because of competition from petroleum-based products. However, the steel companies attempt to use as many coke byproducts as possible in their operations.

Coke trade usually is small, but large fluctuations, mainly because of cyclical demand, can occur. In 1975 shipments of some 106,000 tons, valued at $3.6 million, were exported to three countries, with the bulk going to the United States. Imports of coke amounted to about 602,000 tons, valued at $52.1 million, with shipments coming from the United States and West Germany.

In 1975, an average of 1.41 tons of coking coal was required to produce a ton of coke in Canada. The coke rate, the amount of coke consumed per ton of pig iron produced in blast furnaces, was approximately 1,020 pounds, roughly the same as in 1974. Based on these two factors it is estimated that, in 1975, about 1,440 pounds (0.72 ton) of coking coal were required per ton of basic pig iron produced in Canada.

About 95 per cent of the coke produced in Canada is manufactured in standard slot-type ovens at coke oven plants in Ontario, Nova Scotia and Quebec. The three largest are owned and operated by integrated steel companies; The Algoma Steel Corporation, Limited, The Steel Company of Canada, Limited, and Dominion Foundries and Steel, Limited.

The Steel Company of Canada, Limited (Stelco) imports the bulk of its coking coal from subsidiary and joint venture mines in the United States for its coke oven facilities in Hamilton, Ontario. In 1975 some 3.4 million tons of coking coal were charged to coke ovens to produce some 2.3 million tons of coke.

The new Beckley mine in West Virginia in which Stelco has a 12.5 per cent equity interest expanded production in 1975 after initial start-up in 1974. The mine experienced some production problems due to adverse geological conditions. At capacity of 1.5 million tons annually, Stelco's share of Beckley production is to be 187,500 tons yearly.

At Stelco's Griffith iron ore mine in northwestern Ontario a SL/RN kiln started operation in mid-year. This direct-reduction process uses Alberta subbituminous coal as the reducing agent in the production of concentrated metallic iron. Several difficulties were encountered during the year and the unit processed only 16,000 tons of iron. Design capacity is 350,000 tons annually.

Stelco also purchased coking coal during 1974 from McIntyre Mines and Kaiser Resources for use in its blast furnaces in Hamilton. Late in the year it was announced that Stelco had reached agreement with Devco in Nova Scotia to purchase 500,000 tons of coking coal annually for five years commencing in late 1976. Stelco is also investigating equity participation in western Canada coal properties for medium to long term development.

The Algoma Steel Corporation, Limited (Algoma) of Sault Ste. Marie, Ontario produced some 1.4 million tons of coke in 1974 from 1.9 million tons of coking coal. During 1975 the new No. 9 coke battery came on line and rehabilitation of the No. 7 coke battery was completed. Construction of the No. 10 coke battery has been temporarily delayed, with completion now scheduled for 1979. A new coke oven byproduct plant is presently under construction.

Table 11. Coke oven and other carbonization plants in Canada

Company	Battery and No. of Ovens	Oven Type	Year Built	1975 Plant Capacity (coal input)	1975 Coke Production	Byproducts
				(thousands of tpy)		
The Algoma Steel Corporation, Limited, Sault Ste. Marie, Ontario	No. 5 — 86	Koppers-Becker Underjet	1943	3,000	1,365	Tar, light oil, gas
	No. 6 — 57	Koppers-Becker Underjet	1953			
	No. 7 — 57	Wilputte Underjet	1958			
	No. 8 — 60	Wilputte Underjet	1967			
	No. 9 — 60	Wilputte Underjet	1975			
	No.10 — 60	Wilputte Underjet	To be completed in 1979			
The Steel Company of Canada, Limited, Hamilton, Ontario	No. 3 — 61	Wilputte Underjet	1947	3,400	2,294	Tar, gas, light oil Anhydrous ammonia
	No. 4 — 83	Wilputte Underjet	1952			
	No. 5 — 47	Wilputte Underjet	1953			
	No. 6 — 73	Otto Underjet	1967			
	No. 7 — 83	Otto Underjet	1972			
Nanticoke, Ontario	No. 1 — 45	Otto Underjet	Under construction			
Dominion Foundries and Steel, Limited, Hamilton, Ontario	No. 1 — 25	Koppers-Becker Gun Type Comb	1956	1,800	1,271	Tar, light oil, gas, ammonium sulphate, sulphur
	No. 2 — 35	Koppers-Becker Gun Type Comb	1951			
	No. 3 — 45	Koppers-Becker Gun Type Comb	1958			
	No. 4 — 53	Koppers-Becker Gun Type Comb	1967			
	No. 5 — 53	Koppers-Becker Gun Type Comb	1971			
	No. 6 — 35	Didier	To be completed in 1978			
Sydney Steel Corporation, Sydney, Nova Scotia	No. 5 — 53	Koppers-Becker Underjet	1949	900	430	Tar, light oil, gas
	No. 6 — 61	Koppers-Becker Underjet	1953			
Gaz Métropolitain, inc., Ville la Salle, Quebec	No. 1 — 59	Koppers-Becker	1928	345	192	Tar, light oil, gas
	No. 2 — 15	Koppers-Becker	1947			
Manitoba and Saskatchewan Coal Company (Limited), Char and Briquetting Division, Bienfait, Saskatchewan	2 units	Lurgi carbonizing retort	1925	110	27 (char)	Creosote, lignite tar, lignite pitch
Kaiser Resources Ltd., Natal, British Columbia	10 units	Curran-Knowles	1939	245	160	Crude tar, gas, coke breeze
	10 units	Curran-Knowles	1943			
	16 units	Curran-Knowles	1949			
	16 units	Curran-Knowles	1952			

Algoma's Cannelton Industries, Inc. subsidiary, which operates Algoma's coal mines in the United States, produced 2.1 million tons of coking coal in 1975. Algoma's new Maple Meadow mine in West Virginia that came on stream in late 1974 continued to expand production. Design capacity is 1.25 million tons annually. Starting in 1976, 400,000 tons of annual production from this mine are to be sold to Stelco. During the year Algoma carried out studies on several optioned coking coal properties in West Virginia.

Dominion Foundries and Steel, Limited's (Dofasco's) coke oven plant at Hamilton produced some 1.3 million tons of coke in 1975. Capacity will be increased when a new coke oven battery of 35 ovens capable of producing some 460,000 tons of coke annually comes on stream in 1978. Dofasco's annual coking coal requirements are approximately 1.9 million tons. Coking coal is imported from the United States, with approximately 1.7 million tons, or some 95 per cent of Dofasco's requirements, provided through long-term agreements and the company's 9 per cent interest in ItmannCoal Company of West Virginia. The balance is supplied by spot market purchases. Approximately one million tons annually is supplied by the Eastern Associated Coal Corp. and some 250,000 tons by Itman. Dofasco is pursuing both ownership interests and long-term purchase agreements in western Canada and the United States for future supplies of coking coal. In 1975, Dofasco tested coal shipments from Kaiser Resources Ltd. and Cardinal River Coals Ltd.

During 1975 the coke ovens of Sysco in Sydney, Nova Scotia produced some 430,000 tons of coke from 619,000 tons of coking coal. The bulk of the coal was supplied from Devco's No. 26 colliery at Glace Bay. The remainder of its coal supplies came from McIntyre Mines in Alberta, United States suppliers and from Poland.

The Lasalle Coke Division of Gaz Métropolitain, inc. in Montreal produces coke mainly for foundry use from imported United States coals. In 1975, 192,000 tons of coke were produced. During the year Lasalle tested new coals from both the United States and Canada. A program of reconstruction and modernization of the coke batteries was commenced in 1975.

Kaiser Resources Ltd. produces coke at its plant at Natal, British Columbia. In 1975, approximately 160,000 tons of coke were produced from coal produced at the nearby Michel Colliery. This coke is sold mainly for use in nonferrous smelters.

At Bienfait, Saskatchewan, the Manitoba and Saskatchewan Coal Company (Limited) produced about 27,000 tons of char from lignite during 1975. A large portion of the char is exported to the United States. A program to modernize the char facilities commenced in 1975 and is expected to be completed in 1976. The new plant will utilize many of the lignite char byproducts which are produced in the carbonization process.

Table 12. Canada, coal coke production and trade, 1974-75

	1974		1975^p	
	(short tons)	($)	(short tons)	($)
Production				
Ontario	5,100,000	*	4,995,139	*
Other provinces	900,351	*	822,680	*
Total	6,000,351	*	5,817,819	*
Imports				
United States	415,250	21,929,000	560,694	47,311,000
West Germany	80,258	8,007,000	41,671	4,815,000
United Kingdom	65,632	5,594,000	—	—
Total	561,140	35,530,000	602,365	52,126,000
Exports				
United States	177,976	7,640,000	71,706	2,666,000
West Germany	74,328	1,304,000	—	—
Netherlands	18,268	279,000	17,239	532,000
Japan	17,012	231,000	—	—
Spain	—	—	16,996	442,000
Total	287,584	9,454,000	105,911	3,640,000

Source: Statistics Canada.
* Practically all coke production is used by producers in the iron and steel industry and is not given a value.
^{p} Preliminary; — Nil

Table 13. Canada, coke production and trade, 1965-1975

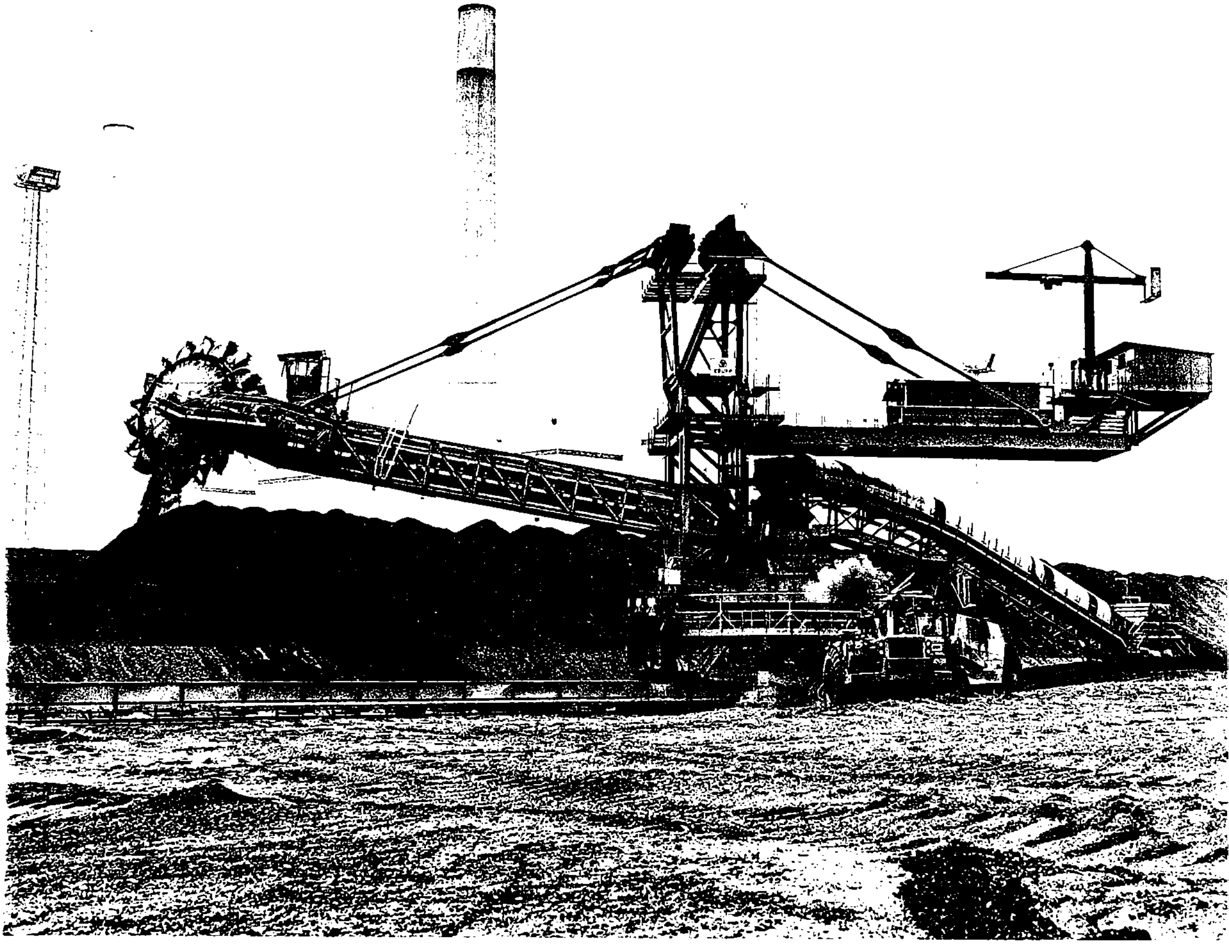
Year	Production		Imports		Exports	
	Coal Coke	Petroleum Coke	Coal Coke	Petroleum Coke	Coal Coke	Petroleum Coke
			(short tons)			
1965	4,368,791	242,813	569,905	413,047	71,531	17,101
1966	4,426,051	230,119	584,965	499,154	77,952	9,668
1967	4,430,299	227,886	387,049	565,836	65,292	18,641
1968	5,310,762	238,601	255,405	561,407	143,771	5,740
1969	5,002,275	231,679	280,905	703,582	272,997	2,606
1970	5,668,219	207,649	394,953	779,079	273,890	53,289
1971	5,105,792	206,439	646,428	733,890	317,765	12,314
1972	5,154,260	267,167	509,065	612,565	262,877	971
1973	5,919,259	315,845	394,424	702,904	405,558	2,167
1974	6,000,351	302,487	561,140	822,361	287,584	27,492
1975[p]	5,817,819	298,379	602,365	631,136	105,911	178,107

Source: Statistics Canada.
[p] Preliminary.

Table 14. World coal production

	1970	1971	1972	1973	1974[p]
			(thousands of short tons)		
North America	622,918	574,557	619,698	619,005	630,295
South America	7,777	8,031	8,586	8,194	8,495
Europe	1,782,768	1,897,001	1,791,355	1,822,151	1,810,207
Africa	63,227	67,826	68,066	72,679	75,725
Asia	558,517	556,275	564,121	590,605	614,755
Oceania	83,524	82,132	94,322	96,790	104,079
World					
Lignite (estimate)	869,626	881,458	886,837[r]	903,852[r]	918,117[e]
Bituminous and anthracite (by subtraction)	2,249,105	2,304,364	2,259,311	2,305,572	2,325,439
Total, all types	3,118,731	3,185,822	3,146,148[r]	3,209,424[r]	3,243,556[e]

Source: U.S. Bureau of Mines.
[p] Preliminary: [r] Revised; [e] Estimated.



Coal stacker-reclaimer in operation at Ontario Hydro's generating station near Sarnia
(Photo courtesy Ontario Hydro)

Cobalt

MICHEL A. BOUCHER

Demand for cobalt in 1975 decreased considerably throughout the world. Mine production also decreased, because most cobalt production is a byproduct of copper and nickel mining operations, and during 1975 both copper and nickel production were down by some 5 per cent. Because of a lower demand for cobalt, sales by the General Services Administration of the United States were reduced considerably.

The Republic of Zaire accounts for about 60 per cent of total world production of cobalt. In 1975 production from Zaire was reduced by some 12 per cent. In the United States, the major market, consumption of cobalt decreased by 40 per cent. Even though production and consumption decreased, the price for shot/cathode cobalt increased from $3.75 a pound to $4.00 in 1975.

Canadian production, developments and consumption

The three producers of cobalt in Canada: The International Nickel Company of Canada, Limited (Inco); Falconbridge Nickel Mines Limited, and Sherritt Gordon Mines Limited, produced a total of 2,949,000 pounds of contained cobalt in 1975.

The largest producer is Inco, which recovers cobalt in the form of crude oxide at its nickel refineries at Port Colborne, Ontario and Thompson, Manitoba. Ungraded cobalt oxides and salts are recovered at the company's nickel refinery at Clydach, Wales. Falconbridge Nickel Mines Limited recovers cobalt at its refinery in Kristiansand, Norway. Sherritt Gordon Mines Limited recovers metal powder from nickel refinery end-solutions at its hydrometallurgical refinery at Fort Saskatchewan, Alberta. The refinery treats nickel-copper concentrates from its Lynn Lake mine operation in Manitoba and also, on a toll basis, concentrates from the Giant Mascot Mines Limited mine near Hope, British Columbia, and from Western Mining Corporation Limited's nickel operation in Western Australia.

During the year, Falconbridge sold the property it had acquired at Becancour, Quebec. Falconbridge was to build a refinery that would produce 500,000 pounds of high-purity salts a year but these plans were terminated with the sale of the property. Canadian consumption of cobalt in metal, oxides and salts is in the order of 400,000 pounds a year, or roughly one-tenth of the Canadian production.

World developments

No new mine production of cobalt was recorded in 1975. Some cobalt will be produced in 1976 from three new nickel producers in Australia, Botswana, and the Philippines; however, no figures as to what the production will be are available.

Deepsea Ventures, Kennecott Copper Corporation and Lockheed Ocean Systems reported before the U.S. Senate in November 1975 that the engineering technology for the recovery of nodules is established. Several refining processes have been evaluated and piloted. Cobalt production from deep-sea mining of the nodules is expected to become a reality between 1980 and 1985.

Current technology and uses

The major applications of cobalt materials are currently divided between four principal markets: the fields of heat-resisting alloys and superalloys, the permanent magnet materials; tool, die and wear-resistant alloys; and nonmetallic uses.

The largest application is in high temperature, cobalt-base alloys used in parts such as nozzle guide vanes and turbine rotor blades in the gas turbine industry. Cobalt-base superalloys are continuing to increase in importance in the fields of industrial and marine turbine applications, especially with the increasing development of high-chromium compositions having high-oxidation and corrosion resistance. Continuing development of the superalloy field is strongly dependent on the aerospace industry and increasing applicability in the pyrometallurgical and chemical industries.

The use of cobalt in various magnetic materials continues to expand, especially in the electronic and electrical industries. The principal types of cobalt-containing magnet materials are the magnet steels used for soft and permanent magnets, with cobalt contents varying from a fraction of one per cent to more than 50

Table 1. Canada, cobalt production, trade and consumption, 1974-75

	1974		1975[p]	
	(pounds)	($)	(pounds)	($)
Production[1] (all forms)				
Ontario	2,775,392	8,141,841	2,406,000	9,439,000
Manitoba	671,686	1,972,068	543,000	2,139,000
Total	3,447,078	10,113,909	2,949,000	11,578,000
Exports				
Cobalt Metal				
United States	1,006,569	3,472,000	866,814	3,353,000
South Africa	16,052	171,000	43,359	442,000
Sweden	136	1,000	11,618	107,000
France	13,911	52,000	17,600	75,000
United Kingdom	8,411	46,000	6,667	57,000
Finland	—	—	1,126	10,000
Japan	6,355	29,000	1,200	5,000
Other Countries	5,406	16,000	730	6,000
Total	1,056,840	3,787,000	949,114	4,055,000
Cobalt oxides and hydroxides[2]				
United Kingdom	1,444,500	3,241,000	1,236,200	2,836,000
Total	1,444,500	3,241,000	1,236,000	2,836,000
Consumption[3]				
Cobalt contained in:				
Cobalt metal	281,858	. .	215,432	. .
Cobalt oxide	46,526	. .	39,426	. .
Cobalt salts	80,445	. .	16,319	. .
Total	408,829	. .	271,177	. .

Source: Statistics Canada.
[1]Production (cobalt content) from domestic ores. [2]Gross weight. [3]Available data reported by consumers.
[p] Preliminary; — Nil; . . Not available.

per cent. The Alnico steels containing aluminum, nickel and cobalt are used extensively in d.c. electrical motors and generators, where they compete directly with another group of cobalt-containing materials called ferrites — magnetic iron oxides — such as $CoFe_2O_4$. The most recently developed, permanent magnet alloys are cobalt-rare earths high-energy magnets containing 60 to 70 per cent cobalt. Because of their high costs, however, these magnets are restricted to use in high-performance instruments produced in limited quantities. Their costs would be reduced by the development of high-volume use such as an in-house application.

Other uses of metallic cobalt are the production of wear-resistant alloys for high-speed tools, cemented carbides, glass-metal seal alloys in the scientific and engineering industries, and springs and balance wheels in precision instruments such as watches. Certain Co-Cr alloys are also finding increased acceptance in the dental and surgical fields as prosthetic devices, and in surgical implants.

Non-metallic uses of cobalt are also increasing and now consume 30 per cent of total cobalt production in such applications as driers in paints, varnishes, printing inks and enamels, and in chemicals, pigments and animal feeds. Increasing uses are being found for cobalt as catalysts, especially the new cobalt-molybdenum catalyst used for the desulphurization of oil and gas.

Prices

The published price for cobalt metal was increased from $3.75 a pound to $4.00 in January 1975.

Table 2. Canada, cobalt production and consumption 1966-75

	Production[1]	Exports: Cobalt Metal	Exports: Cobalt Oxides and Hydroxides	Consumption[2]
		(pounds)		
1966	3,511,169	627,990	1,308,300	392,177
1967	3,603,773	1,498,559	1,934,500	293,086
1968	4,029,549	1,210,909	1,646,500	358,098
1969	3,255,623	1,155,291	1,199,800	393,658
1970	4,561,213	839,849	1,845,000	327,030
1971	4,323,318	748,502	2,466,500	220,994
1972	3,351,108	860,481	1,615,700	381,260
1973	3,344,352	1,214,374	1,129,600	431,420
1974	3,447,078	1,056,840	1,444,500	408,829
1975^p	2,949,000	949,114	1,236,200	. .

Source: Statistics Canada.
[1]Production from domestic ores, cobalt content. From 1967, production includes cobalt content of Inco and of Falconbridge Nickel Mines Ltd. shipments to overseas refineries, but prior years exclude Inco shipments to the United Kingdom. [2]Consumption of cobalt in metal, oxides and salts.
^{p} Preliminary; — Nil; . . Not available.

Table 3. World production of cobalt 1973-75

	1973	1974	1975^p
	(short tons of contained cobalt)		
Republic of Zaire	16,625	19,340	17,000
Zambia	3,460	3,490	3,500
U.S.S.R.	1,850	1,900	1,900
Morocco	1,567	1,932	1,900
Cuba	1,800	1,800	1,800
Canada	1,672	1,724	1,475
Finland	1,400	1,400	1,400
Australia	848	850	800
Other countries	46	672	600
Total	29,268	33,108	30,375

Sources: U.S. Bureau of Mines, *Minerals Yearbook 1974 Preprint for 1973-74;* for 1975 *U.S. Commodity Data Summaries* January 1976; for Canada, Statistics Canada.
^{p} Preliminary.

Table 4. United States, consumption of cobalt by uses, 1973-74

	1973	1974
	('000 lbs. cobalt content)	
Steel (Ingots & castings)		
High-speed and tool	518	690
Stainless steel	32	39
Alloy (excluding stainless and tool)	273	262
Cutting and wear-resistant materials		
Cemented or sintered carbides	2,511	2,578
Other materials	4,037	4,729
Welding and hardfacing rods materials	391	423
Magnetic alloys	4,302	3,457
Non-ferrous alloys	789	780
Electrical materials	. .	. .
Chemical and Ceramic uses		
Catalysts	1,150	1,378
Ground coat frit	165	133
Glass decolorizer	64	51
Pigments	217	192
Other	197	151
Miscellaneous and unspecified	526	363
Salts and driers; lacquers, varnishes, paints, inks, pigments enamels, feeds electroplating (estimate)	3,569	3,635
Total	18,741	18,861

Sources: U.S. Bureau of Mines, *Minerals Yearbook, 1973* and preprint from the U.S. Bureau of Mines. *Minerals Yearbook, 1974.*
. . Not available.

Prices of cobalt in U.S. currency

	Dec. 1974	Dec. 1975
	(U.S.$)	(U.S.$)
Cobalt metal per lb fob New York, Chicago		
Shot 99%+		
less than 50 Kg	3.85	4.10
50-Kg drums	3.80	4.05
250-Kg	3.75	4.00
Powder, 99%+, 300 & 400 mesh		
50-Kg drums	5.07	5.41
extra fine, 125-Kg drums	6.61	7.05
S grade, 10-ton lots	4.00	4.00

Source: *Engineering Mining Journal*, December 1974 and 1975.

Table 5. Tariff profile (most favoured nation — comparative ad valorem equivalents)

Brussels Tariff Nomen-clature	Description	United States	European Economic Community	Japan	Canada	Cdn. Tariff No.
26.01	Cobalt ores and conc.	Free	Free	Free	Free	33200-1
28.24	Cobalt oxides, etc.	0.5 to 6%	6.4%	Free	10 to 15%	92824-1-2
.38	Cobalt sulphates, etc.	1.2¢/lb	8%	7.5%	Free to 15%	92838-1
81.04	Coblat metal					
	Unwrought	Free-9%	Free	Free	Free	35103-1
	Waste and scrap	Free	Free	Free	Free	
	Wrought	9%	5%	Free	Free	35103-1

Columbium (Niobium) and Tantalum

MICHEL A. BOUCHER

Columbium

Even though world consumption of columbium declined by an estimated 20 per cent in 1975, demand for columbium concentrates produced by Canada's only producer, St. Lawrence Columbium and Metals Corporation (SLC), near Oka, Quebec, remained strong because of pipeline construction activities in the European countries that import SLC's concentrates.

Due to an anticipated strong demand for columbium in energy transmission such as oil and gas pipelines, in transportation, and in other uses where high strength low alloy (HSLA) steels are used to reduce weight and increase yield strengths, SLC is working on an expansion program that will raise its production capacity from 5.5 million pounds of Cb_2O_5 a year to 7 million pounds by 1977. SLC intends to reactivate its ferroalloy plant in 1976 and make ferrocolumbium. The company also intends to eventually make other ferroalloys such as ferrovanadium and ferrotungsten.

HSLA steels were virtually unknown 15 years ago, but last year in the United States some 1.3 million pounds of Cb were consumed in the form of ferrocolumbium in the production of HSLA steels. Acceptance of columbium in modern steelmaking can be traced to its ability to increase strength by as much as 50 per cent. Carbon and titanium also strengthen steel but they may impair toughness and weldability. Strengths of columbium steels range up to 80 kilograms per square inch (ksi) in sheet and up to 70 ksi in pipe. For highest strength levels a basic columbium steel may be fortified with a supplementary addition of vanadium. In North America most of the large-diameter transmission pipes installed use columbium. Columbium's advantage over its alternate, vanadium, is in net cost. For example, it requires 0.72 pounds Cb or 1.66 pounds V to increase the strength of one ton of an average structural carbon steel by 15 ksi. With ferrocolumbium costing $4.00 a pound and ferrovanadium costing $5.00 a pound (1975 prices), this represents a difference between $2.88 and $8.30 a ton.

Canadian production and developments

In 1975, St. Lawrence Columbium and Metals Corporation with mine, mill and concentrator near Oka, Quebec, continued to be Canada's sole producer of columbium, and along with the larger operation of Companhia Brasileira de Metalurgia e Mineracao (CBMM) at Araxa, Brazil, it is one of only two mines in the world producing columbium in pyrochlore concentrates as a primary product. Canada's production (shipments) of columbium pentoxide (Cb_2O_5) contained in concentrates in 1975 were 3,714,000 pounds valued at $6,430,000 compared with 4,233,055 pounds of Cb_2O_5 valued at $6,680,316 in 1974. Most of the Canadian production is exported in the form of concentrates containing from 51 to 54 per cent Cb_2O_5, mainly to Britain, West Germany, France, Italy and Austria where it is transformed into ferrocolumbium for use by the steel industry.

Some of the Canadian production is converted to ferrocolumbium by St. Lawrence Columbium and Metals Corporation near Oka, Quebec; by Masterloy Products Limited, at Gloucester, near Ottawa; and by Fundy Chemical International Ltd., at Duparquet, Quebec.

Niobec Inc., owned 50 per cent by Quebec Mining Exploration Company (Soquem) a Quebec Crown Corporation, 25 per cent by Teck Corporation Limited and 25 per cent by Copperfields Mining Corporation, plans to start producing columbium concentrates in mid-January, 1976. The mine and mill are at St. Honore, Quebec, near Chicoutimi. The mine ore grades 0.75% Cb_2O_5 and reserves to a depth of 850 feet available for underground mining (open stope) are 40 million tons. The ore is medium grained, which is a favourable characteristic for the production of ferrocolumbium. The mill, with a capacity of 1,500 tons a day, will be able to produce 5.5 million pounds of columbium pentoxide a year and has been designed so that capacity can be expanded quickly if desired. Niobec will make a concentrate grading 60 per cent Cb_2O_5. About 55 per cent of the mine's output has already been sold on long-term contracts to Continental Alloys S.A. of Luxembourg. Another 15 per cent will go to Metallurg Inc. of New York and the remaining 30 per cent to the Japanese market through Mitsui interests. Prices on the shipments which will begin in 1976 have not been fixed yet; however, will be negotiated on a quarterly basis.

World developments

During the year the General Services Administration of the United States (GSA) depleted its stockpile of columbium ores and concentrates that were authorized for sale.

CBMM is still working on an expansion program that will raise its production capacity from 30 million pounds to about 50 million pounds of columbium oxide a year. In 1974, the year for which the latest statistics are available, CBMM exported some 14.5 million pounds of contained Cb in the form of ferrocolumbium and pyrochlore concentrates. About 45 per cent of CBMM's exports go to Europe, 30 to 35 per cent to the U.S. and 10 per cent to Japan. The rest goes to various other countries, including Eastern Europe.

Minerals and Canadian occurrences

The predominant commercial minerals of columbium and tantalum are the columbite-tantalite mineral series and the pyrochlore-microlite series. Columbite-tantalite have the theoretical composition $(Fe,Mn)OCb_2O_5$ and $(Fe,Mn)OTa_2O_5$ and occur as accessory minerals in pegmatites and residual placer deposits. The pyrochlore-microlite series have theoretical compositions $Na\ Ca\ Cb_2O_6F$ and $(Na, Ca)_2(Cb, Ta)_2O_6F$, often exhibiting pronounced enrichment in rare-earths and radioactive minerals, and occur almost exclusively in carbonatite-alkalic rock complexes.

The major source of the world columbium supply is from columbium-bearing pyrochlore occurring as an accessory mineral in the carbonatite complexes in Canada and Brazil. Columbite and tantalite are alternative sources of columbium and are recovered as coproducts of tin and alluvial deposits, notably in Nigeria, where concentrates containing 65 per cent or more of the combined oxides of columbium and tantalum are obtained.

There are 30 or more known carbonatite occurrences in Ontario and several in Quebec, Labrador, British Columbia and the Northtwest Territories. The major occurrences of columbium minerals in carbonatite complexes include:

— in Quebec; near Oka, the columbium pyrochlore producing mine of St. Lawrence Columbium and Metals Corporation; the property

Table 1. Canada, columbium (niobium) and tantalum production, trade and consumption, 1974-75

	1974		1975^p	
	(pounds)	($)	(pounds)	($)
Production				
Columbium (Cb_2O_5 content of shipments)	4,233,055	6,680,316	3,714,000	6,430,000
Tantalum (Ta_2O_5 content of shipments)	438,442	3,576,026	395,000	3,260,000
Imports[1] from United States				
Columbium and columbium alloys wrought	4,391	30,309	—	—
Tantalum and tantalum alloys wrought, nes	5,137	324,435	—	—
Tantalum and tantalum alloys, unwrought waste and scrap	—	—	—	—
Tantalum and tantalum alloy powder	12,483	292,653	—	—
Exports[2] to United States				
Columbium ore and concentrates	8,671	7,614	—	—
Consumption by the steel industry				
Ferrocolumbium and ferrotantalum-columbium (Cb and Ta-Cb content)	510,000	. .		. .

Source: Statistics Canada, unless otherwise noted.
[1]From U.S. Department of Commerce, *Export of Domestic and Foreign Merchandise,* Report Ft 410. Values in U.S. currency. [2]From U.S. Department of Commerce, *Imports of Merchandise for Consumption,* Report FT 135. Values in U.S. currency.
^{p}Preliminary; . . Not available; — Nil.

Table 2. Canada, columbium (niobium) and tantalum production, trade and consumption, 1965-75

	Production[1]		Imports[2], from U.S.					
	Cb_2O_5 Content	Ta_2O_5 Content	Columbium and Alloys, Wrought	Tantalum and Alloys, Wrought	Tantalum and Alloys, Unwrought Waste and Scrap	Tantalum and Alloys, Powder	Exports[3], Columbium Ores and Conc., to U.S.	Consumption, Ferro. and ferrotantalum-columbium Cb and Ta-Cb Content
	(pounds)							
1965	2,333,967	—	—	721	—	—	1,860,631	58,000
1966	2,637,997	—	—	1,533	—	2,730	1,524,279	40,000
1967	2,159,557	—	185	1,245	34,914	1,155	890,884	78,000
1968	2,181,304	—	375	1,972	3,433	1,830	295,333	288,000
1969	3,414,495	130,298	1,178	1,871	4,405	7,488	919,577	244,000
1970	4,694,239	317,024	—	854	1,870	2,480	1,270,362	292,000[r]
1971	2,332,663	449,610	5,061	1,487	14,237	3,100	341,237	390,000[r]
1972	3,873,787	41,120	1,633	1,160	3,175	1,446	65,113	580,000
1973	3,176,895	170,582	2,636	5,437	—	16,527	667	452,000
1974	4,233,055	438,442	4,391	5,137	—	12,483	8,671	510,000
1975[p]	3,714,000	395,000	—	—	—	—	—	

Source: Statistics Canada, unless otherwise noted.
[1]Producers' shipments of columbium and tantalum ores and concentrates and primary products, Cb_2O_5 and Ta_2O_5 content. [2]From U.S. Department of Commerce, *Exports of Domestic and Foreign Merchandise,* Report FT 410. Quantities in gross weight of material. [3]From U.S. Department of Commerce, *Imports of Merchandise for Consumption,* Report FT 135. Quantities in gross weight.
[p] Preliminary; . . Not available; — Nil; [r] Revised.

of Columbium Mining Products Ltd.; the property of Main Oka Mining Corporation; and the property of Columbium Limited; and, near Chicoutimi, the St. Honore deposits of Quebec Mining Exploration Company (SOQUEM) and Copperfields Mining Corporation.

— in Ontario; the James Bay property of Imperial Oil Enterprises Ltd., and Consolidated Morrison Explorations Limited and associated companies; the Manitou Island deposit of Nova Beaucage Mines Limited near North Bay; the Lackner Lake property of Multi-Minerals Limited near Chapleau; and the Nemegosenda Lake property of Dominion Gulf Company near Chapleau.

Current technology and uses

The steel industry is the predominant consumer of columbium in the form of ferrocolumbium, which is used as an additive agent in the production of four major classes of steel; high-strength low-alloy carbon steel, stainless steels, low-alloy steels and superalloys. Pre-eminent amongst these steels in terms of present columbium consumption are the HSLA steels, in which the addition of 0.03 — 0.07 per cent columbium controls and refines the grain size, improving impact properties and tensile strength. Strengths of columbium steels range up to 70,000 psi as compared with 35,000 psi for structural carbon steel. HSLA steels have found widespread application in the construction of oil and gas transmission pipelines. Canadian natural gas pipelines commonly use Arctic grade X-65 HSLA steel containing 0.06 per cent columbium and 0.042 per cent carbon, which yields high strength-to-cost ratio and excellent weldability properties. About 33 per cent of total HSLA tonnage produced employs columbium. Of the remaining 67 per cent, about two-thirds goes into automotive uses. Considering the properties and technologies desired in the automotive industries Cb-HSLA steel would appear to have a strong potential for greater penetration of this giant market in future years. Currently, each vehicle contains an average of 70 pounds. By 1980 it is forecast that the average will be 200 pounds, due to the need to make cars lighter (but just as strong) in order to cut down on fuel consumption.

HSLA steels are also finding increasing application as structural steels in stadia, bridges and buildings, such as the World Trade Centre in New York. HSLA steels are used in various permutations with other additive materials such as molybdenum, cerium and vanadium

Table 3. Production of columbium (Cb) and tantalum (Ta) concentrates, 1972-74[1,2]

	1972			1973			1974^p		
	Cb	Ta	Cb-Ta	Cb	Ta	Cb-Ta	Cb	Ta	Cb-Ta
				(thousands of pounds gross)					
Brazil									
Pyrochlore	21,242	—	—	42,827	—	—	39,414	—	—
Columbite-tantalite	143	660	—	373	—	—	485^e	—	—
Canada									
Pyrochlore	7,756^e	—	—	6,360^e	—	—	8,234^e	—	—
Tantalite	—	77^e	—	—	318^e	—	—	802^e	—
Nigeria	3,000	2	—	2,734	2	—	2,884	—	—
Zaire	—	—	214	—	—	102	—	—	102
Mozambique									
Columbite-tantalite	—	93	—	—	64	—	—	88	—
Microlite	—	134	—	—	123	—	—	117	—
Malaysia	—	—	194	—	—	203	—	—	132^e
Thailand	11	20	—	18	35	—	68	134	—
Portugal	—	26	—	—	26	—	—	26	—
Rwanda	84	—	—	72	—	—	73^e	—	—
South Africa (Rep. of)	—	—	—	—	—	—	—	—	—
Australia	—	—	558	—	—	441	—	—	441^e
Other countries[3]	1	4	96^e	3	2	96^e	3^e	2^e	98^e
Total	32,237	1,016	1,062	52,387	570	842	51,161	1,169	773

Source: U.S. Bureau of Mines *Minerals Yearbook* 1974 Preprint.
[1]Excludes tin slag bearing columbium-tantalum [2]Concentrates containing important amounts of both elements are shown under Cb-Ta when composition data is insufficient. [3]Other countries that produce columbium and/or tantalum minerals include: Argentina, Rhodesia and Uganda.
^{p} Preliminary; — Nil; ^{e} Estimated.

in the construction of ships, storage tanks, highway guard rails, railroad cars and electrical transmission poles.

Columbium is one of the two or three most promising materials for the severe requirements of "first-wall" thermonuclear reactors. Since Cb-Ti super-conductor wire is already cost-competitive with its copper counterpart on a current-carrying basis, columbium may find increasing superconductor application in the next few years.

Prices

The price of Canadian Pyrochlore remained at $1.80 a pound of contained Cb_2O_5 during 1975. SLC has indicated, however, that the price may rise to between $2.00 and $2.15 in January 1976.

The price for low-alloy ferrocolumbium was raised from $3.65 to $4.30.

Tantalum

Demand for tantalum declined sharply in 1975, reflecting worldwide depressed economic conditions. The electronics market which accounts for about two-thirds of tantalum consumption was especially hard hit by the recession. Demand for tantalum is expected to be stronger in 1976 even though consumption will probably be below that of 1974.

Canadian production and developments

In 1975, shipments by Tantalum Mining Corporation of Canada Limited (Tanco) were not affected by the lower demand for tantalum because all of Tanco's production is sold under firm contract for the next five years.

Shipments by Tantalum Mining Corporation of Canada Limited (Tanco) during 1975 were 395,000 pounds of Ta_2O_5 contained in concentrates, and shipments for 1976 are expected to be about 400,000 pounds. The Tanco plant and mill operate at the rate of 175,000 tons of ore a year. Ore reserves calculated from diamond drill intersections, at the end of December 1975, were 937,000 tons grading 0.15 per cent, for a total of 2,811,000 pounds. The ore occurs in a pegmatite and there is a possibility of finding more ore in different sections. Because proven reserves will last for only about seven years at 1975 production rates, the company intends to spend some $250,000 on an exploration program in 1976.

During 1975, Tanco invested $700,000 to construct a slime recovery plant. The new plant came into operation in October. It makes use of a combination of fine screening, concentrators, and vibrating tables. Management reports that recovery will improve from 60-65 per cent to 75-80 per cent. This will have a significant effect on output, earnings and the life of the mine. Manage-

Table 4. United States shipments of tantalum products 1970-1974

Product	1970	1971	1972	1973	1974
	(thousand of pounds of contained Ta)				
Tantalum					
Oxides & Salts	90.2	60.9	54.9	142.3	226.1
Alloy Additive	29.2	48.8	43.0	17.3	24.8
Carbide	145.6	135.0	146.9	173.4	163.4
Powder & Anodes	498.7	398.7	540.7	790.5	929.4
Ingot	54.4	42.4	(1.9)	16.0	1.7
Mill Products	213.3	223.3	246.4	321.2	288.8
Scrap	78.6	52.4	58.1	40.5	45.6
Other	9.2	—	.3	1.3	1.3
Total	1,118.2	961.5	1,088.4	1,502.5	1,681.1

Source: U.S. Bureau of Mines, Department of the Interior.

ment is also planning to re-treat tailings that have now become economic.

In March 1975 Tanco was placed in receivership upon alleged default on a loan, but the company continues to operate while the case is still before the courts. For this reason Tanco had to delay, at least temporarily, other financing arrangements and agreements that it had planned for the expansion of its tantalum mine and work on other properties.

World production, consumption and developments

Tantalum production in 1975 is estimated by Newmont Services Ltd. of the United States, to have been 1.8 million pounds of Ta_2O_5. The breakdown by countries is as follows: Canada, 400,000 lb; Thailand, 450,000 lb in tin slag and 50,000 lb in concentrates; Brazil, 125,000 lb; Australia, 85,000 lb; Malaysia, 100,000 lb; Mozambique, 40,000 lb; Portugal, 30,000 lb; Zaire and other African countries 180,000 lb; other sources, 260,000 lb. In addition, some 80,000 pounds was released by the General Services Administration of the United States from the national stockpile.

Consumption in the United States, Japan and Europe decreased in 1975, reflecting the general economic recession. Computer, communication, and industrial markets were all affected. For example, in 1975 some 350 million tantalum capacitors were shipped to the electronics component manufacturers in the United States, compared with 600 million devices in 1974. In 1976, U.S. capacitor shipments are projected at 450 million devices.

Output from the Thaisarco tin smelter in Thailand, an important producer of tantalum-rich tin slag decreased by 30 per cent in 1975. This was due to cancellation of the Tanco tin mining concessions by Union Carbide Corporation. Much of the feed for the smelter is derived from these concessions. No new sources of tantalum are reported to be under development in the world.

On July 24, Union Carbide Corporation announced plans to build a multi-million dollar new facility to

Table 5. Tantalum trend applications from the mid-1960's and projected to 1980

Application	Mid-1960's	Mid-1970's	Projected-1980
Military/Aerospace	30%	13%	10%
Computers	49%	30%	20%
Communications	16%	12%	10%
Automotive	0%	18%	25%
Industrial	5%	12%	10%
Entertainment	0%	15%	25%
Total	100%	100%	100%

Source: Tantalum Producers International Study Center, September 1975.

produce solid tantalum capacitors to be located near Columbus, Georgia. The plant will employ about 750 people and will increase Union Carbide's tantalum capacitor capacity by 40 per cent. In September, Fansteel Inc. announced the availability of a new tantalum capacitor powder. The new capacitor is a high voltage, moderate capacitance and high reliability. During the year, GSA released 78,943 pounds of TA_2O_5. The material was sold at an average price of $13.066 a pound. As at June 30, 1975, the GSA stockpile contained 2,613,000 pounds of Ta_2O_5, valued at $45.6 million. Of this, 2,300,000 is classified as excess material.

Products and applications

Table 4 is a summary of United States shipments of tantalum products. Powder and anodes accounted for over 50 per cent of U.S. shipments in 1974.

Table 5 is a summary of tantalum products applications. By 1980 the automotive and entertainment industries will account for about 50 per cent of consumption.

By 1980 forecasts indicate an average of $400 per automobile in electronic equipment, compared with $100 in 1975.

The quantity of tantalum, needed to make 1,000 anodes for tantalum capacitors is about 0.85 pounds. The average unit cost of a tantalum capacitor is $0.20.

Outlook

Demand for tantalum is expected to increase in late 1976. In the meantime the price of concentrate could show some weakness during the year. No new mines are under development and output from tin mining operations is unlikely to increase appreciably in the next couple of years because of price and production controls in the tin mining industry. For these reasons a shortage is possible in 1977. If a shortage does materialize it is likely to result in price increase for tantalite ore, and subsequently tantalum capacitors.

Substitution

In 1973-1974, when tantalite prices tripled, capacitor powder prices increased by 50 per cent. During the same period, tantalum capacitor price increased by an average of 20 to 25 per cent. If the price for tantalum capacitors continues to increase, ceramics and aluminium are likely products to make inroads in the tantalum market.

Prices

At the end of 1975, the posted price of Ta_2O_5, according to *Metals Week,* was $15 a pound. Tantalum powder was selling at $35 to $44 a pound.

United States Prices

United States prices in U.S. currency quoted in Metals Week of December 29, 1975. 1974 year-end prices are shown in brackets when differing.

	($)	
Columbium ore Columbite per lb. pentoxide Nominal spot cif U.S. ports	1.80-1.90	(1.60-1.70)
Pyrochlore per lb Cb_2O_5 Canadian fob mine or mill, contract only	$1.56	
Brazilian fob shipping point, contract only	(1.42)	no quote after Jan. 1973
Ferrocolumbium per lb Cb, ton lots fob shipping point, low-alloy standard grades	4.30	(3.65)
high-purity grade (incl-Ni)	8.61-9.50	(6.82-8.65)
Columbium metal per lb 99.5 to 99.8% free alongside U.S. shipping point		
Tantalum ore Tancotantalite per lb pentoxide	15.00	

	Powder roundel	Ingot
	($)	($)
Reactor	30.00-45.00	18.00-25.00
Tantalum metal per lb powder fob shipping point depending on size of lot		35.40-44.50
Sheet and rod depending on grade		48.00-118.00 (50.00-57.00)

Table 6. Tariff Profile (most favoured nation — comparative ad valorem equivalents)

Brussels Tariff Nomenclature	Description	United States	European Economic Community	Japan	Canada	Cdn. Tariff No.
26.01	Metallic ores & conc.	Free	Free	Free	Free	32900-1
81.03	Tantalum, unwrough	5 to 7.5%	3%	10%	Free	315120-1
	waste & scrap	5%		Free	Free	
	wrought	9%	6%	12%*	Free	
	other	. .	9%	12%*	Free	
81.04	Columbium, unwrought, etc.	7.5%	6%	8%*	Free	315120-1
	wrought	9%	10%	12%*	Free	
73.02	Ferroalloys (includes ferro- Cb,-Ta, Ta-Cb)	5.0%	7%	7%	5%	37506-1

Source: Mineral Development Sector, Department of Energy, Mines and Resources, Ottawa.
* General tariff

Copper

G.E. WOOD

Canadian Mines

Primary copper production in 1975 declined substantially relative to production in 1974. This was the first year-to-year decrease since 1969, when production was affected by lengthy strikes by Sudbury-area employees of The International Nickel Company of Canada, Limited (INCO), and Falconbridge Nickel Mines Limited (Falconbridge Nickel).

An important factor in the decrease in primary copper production was the drop in shipments of copper concentrates to Japan from mines in western Canada. In response to the severe slump in demand for copper, the build-up of very large inventories of refined copper, and a ban on exports of refined copper from Japan, concentrate purchasers in that country made strenuous efforts to reduce shipments from their suppliers. Canadian mines supplying this market were requested to reduce shipments in 1975 below 1974 levels. These requested reductions were, in some cases, as much as 30 per cent of 1974 shipments. Actual copper production by British Columbia mines in 1975 was 16 per cent below 1974 production. This cutback was well above the average for all copper mines in Canada.

As a result of the need to cut 1975 shipments to Japan, and the higher treatment charges sought by Japanese smelters, a significant shift of Canadian concentrate sales away from Japan took place in 1975. This trend is expected to continue in 1976. The displaced concentrates are being processed at smelters in eastern Canada and the United States.

In 1975 a significant erosion of mine production capacity occurred, particularly in eastern Canada, with the closure of a number of small mines due to exhaustion of ore reserves. Six copper-producing mines closed for this reason in Quebec, one in Ontario and two in British Columbia. These mines had a total copper production of 28,000 tons in their last full year of operation.

A number of successful applications of advanced technology in Canadian concentrators were reported in 1975. Computer process control at the milling operations of Brenda Mines Ltd. and Mattagami Lake Mines Limited, improved mill throughput and metallurgical recoveries.

Newfoundland. Consolidated Rambler Mines Limited closed the East Mine and continued to develop and mine the Ming Mine during 1975. The decline advanced by 1,463 feet in the year and a new vertical shaft, the Boundary Shaft was almost completed by year-end.

New Brunswick. Brunswick Mining and Smelting Corporation Limited (Brunswick) continued its project to expand ore production at the No. 12 mine to 11,000 tons a day by 1979 from the present 7,000-ton-a-day capacity. The new No. 12 mine shaft was excavated to the final 26-foot-diameter size to 471 feet below surface, the shaft concrete was completed to 427 feet below the collar and the shaft steel was installed for 226 feet. The No. 12 mine contains a copper deposit which is estimated to contain 14 million tons of copper ore. This deposit could be brought into production in 1982 or 1983. Copper is a coproduct with zinc and lead from present operations.

Heath Steele Mines Limited continued to prepare for an increase in ore production capacity to 4,000 tons a day by the beginning of 1977. Underground ore production was augmented in 1975 by mining remnants of the "A" open pit ore from a decline. Sinking of a new shaft is expected to be completed late in 1977.

Quebec. At the property of the Bouzan Joint venture at Chibougamau there was no production during 1975 due to low metal prices.

Mining operations of Campbell Chibougamau Mines Ltd. were suspended on May 5, 1975 and properties were maintained on a standby basis throughout the rest of the year. Reasons given for the closure were difficult labour relations and the sharp cyclical drop in copper prices.

Falconbridge Copper Limited completed the Cooke shaft at a depth of 1,985 feet at the Cooke Mine in the

Opemiska Division. Extensive lateral development was also completed at the mine. In the Lake Dufault Division, surface plant construction and shaft sinking at the new Corbet ore zone was substantially complete at year-end. This copper-zinc zone, 7,000 feet southwest of the Millenbach mine is to be explored from the new shaft.

At the Murdochville operations of Gaspé Copper Mines, Limited, the concentrator operated at 90 per cent capacity, processing 10,993,105 tons of ore. This compares with an operating rate of 85 per cent of capacity in 1974. In the smelter, production of anode copper was 73,200 tons in 1975 compared with 69,700 tons in 1974.

(text continued on 170)

Table 1. Canada, copper production, trade and consumption 1974-75

	1974		1975^p	
	(short tons)	($)	(short tons)	($)
Production[1]				
Ontario	312,943	483,995,146	292,296	372,385,000
British Columbia	316,968	491,426,167	265,999	338,883,000
Quebec	158,991	246,502,131	129,859	165,440,000
Manitoba	78,356	121,484,109	70,782	90,176,000
New Brunswick	12,532	19,429,203	13,139	16,739,000
Yukon	10,043	15,571,426	9,090	11,580,000
Saskatchewan	8,804	13,650,273	8,502	10,831,000
Newfoundland	6,233	9,664,523	8,190	10,434,000
Northwest Territories	542	840,719	275	351,000
Nova Scotia	5	7,132	—	—
Total	905,417	1,402,570,829	798,132	1,016,819,000
Refined				
	616,329	. .	583,342	. .
Exports				
Copper in ores, concentrates and matte				
Japan	315,540	489,523,000	250,098	222,384,000
United States	22,419	24,376,000	54,170	45,023,000
Norway	26,881	54,455,000	18,609	15,631,000
West Germany	10,752	15,613,000	13,005	9,672,000
Sweden	—	—	3,719	2,754,000
East Germany	—	—	3,059	2,384,000
United Kingdom	1,615	2,151,000	1,683	1,975,000
South Korea	—	—	1,332	946,000
Other Countries	2,021	3,137,000	1,085	560,000
Total	379,228	589,255,000	346,760	301,329,000
Copper in slag, skimmings and sludge				
United States	163	128,000	113	63,000
United Kingdom	80	64,000	—	—
Total	243	192,000	113	63,000
Copper scrap (gross weight)				
United States	8,510	14,227,000	5,944	5,694,000
West Germany	903	1,243,000	3,114	3,217,000
South Korea	1,210	1,516,000	2,553	2,437,000
Spain	922	1,125,000	1,623	1,552,000
Japan	335	324,000	1,539	1,541,000
Belgium and Luxembourg	4,010	6,159,000	1,061	605,000
Italy	241	288,000	550	598,000

Table 1. (cont'd)

	1974		1975p	
	(short tons)	($)	(short tons)	($)
Exports (cont'd)				
United Kingdom	451	323,000	587	447,000
Hong Kong	122	153,000	270	292,000
Taiwan	92	17,000	290	287,000
Netherlands	143	175,000	209	224,000
Other Countries	347	443,000	341	340,000
Total	17,286	25,993,000	18,081	17,234,000
Brass and bronze scrap (gross weight)				
United States	12,080	17,432,000	7,034	6,112,000
Italy	2,290	2,802,000	1,938	1,800,000
Japan	1,539	1,712,000	1,425	1,164,000
Netherlands	159	195,000	696	587,000
West Germany	1,434	2,038,000	618	502,000
United Kingdom	1,077	1,029,000	308	331,000
Spain	198	257,000	267	248,000
Belgium and Luxembourg	2,440	3,164,000	311	244,000
Other Countries	643	731,000	774	665,000
Total	21,860	29,360,000	13,371	11,653,000
Copper alloy scrap, nes (gross weight)				
United States	1,088	1,201,000	952	867,000
Belgium and Luxembourg	510	625,000	201	131,000
Japan	146	167,000	106	91,000
Netherlands	40	50,000	96	85,000
Other Countries	1,179	579,000	324	181,000
Total	2,963	2,622,000	1,679	1,355,000
Copper refinery shapes				
United Kingdom	101,095	165,393,000	103,521	117,825,000
United States	113,844	179,620,000	71,852	93,506,000
West Germany	29,972	49,415,000	51,670	58,702,000
Netherlands	2,305	3,579,000	35,843	40,349,000
France	17,221	28,947,000	24,247	27,280,000
Italy	6,482	10,802,000	16,907	18,786,000
Belgium and Luxembourg	7,069	12,081,000	11,731	13,024,000
Sweden	8,098	13,597,000	9,732	10,822,000
Brazil	2,957	4,783,000	5,288	6,060,000
Switzerland	3,691	6,238,000	5,031	5,644,000
Portugal	3,587	6,223,000	4,683	5,263,000
Taiwan	1,322	2,477,000	4,004	4,510,000
South Korea	—	—	2,231	2,521,000
Japan	3,092	4,699,000	1,597	1,808,000
Other Countries	14,429	25,320,000	3,931	4,556,000
Total	315,164	513,174,000	352,268	410,656,000

Table 1. (cont'd)

	1974		1975[p]	
	(short tons)	($)	(short tons)	($)
Exports (cont'd)				
Copper bars, rods and shapes, nes				
Iran	2,494	5,850,000	4,132	6,732,000
United States	9,183	16,688,000	2,986	4,635,000
Cuba	413	1,001,000	1,350	2,060,000
Switzerland	2,739	5,295,000	1,612	1,918,000
Pakistan	3,117	6,181,000	1,378	1,684,000
Venezuela	2,654	6,399,000	1,108	1,545,000
Nigeria	551	1,397,000	853	1,297,000
Malaysia	250	493,000	887	1,182,000
Dominican Republic	900	1,951,000	899	1,143,000
Other Countries	5,416	11,091,000	1,263	1,659,000
Total	27,717	56,346,000	16,468	23,855,000
Copper plates, sheet, strip and flat products				
United States	8,026	17,716,000	4,724	9,148,000
Venezuela	544	1,536,000	271	606,000
United Kingdom	261	619,000	228	377,000
Thailand	—	—	88	112,000
New Zealand	75	217,000	16	51,000
Norway	24	58,000	10	20,000
Puerto Rico	—	—	6	12,000
Cuba	—	—	3	12,000
Other Countries	78	226,000	2	3,000
Total	9,008	20,372,000	5,348	10,341,000
Copper pipe and tubing				
United States	7,355	12,159,000	4,298	7,008,000
Israel	581	1,431,000	506	1,111,000
West Germany	150	344,000	725	1,059,000
Venezuela	123	473,000	313	899,000
New Zealand	935	2,737,000	203	556,000
United Kingdom	1,968	4,928,000	96	188,000
Spain	172	446,000	84	159,000
Other Countries	1,065	2,990,000	414	936,000
Total	12,349	25,508,000	6,639	11,916,000
Copper wire and cable (not insulated)				
United States	622	1,060,000	408	519,000
Switzerland	—	—	179	211,000
Pakistan	23	37,000	39	60,000
Bangladesh	97	156,000	37	55,000
Other Countries	563	1,180,000	71	176,000
Total	1,305	2,433,000	734	1,021,000

Table 1. (cont'd)

	1974		1975^{p}	
Exports (cont'd)	(short tons)	($)	(short tons)	($)
Copper alloy refinery shapes				
United States	8,347	15,801,000	5,386	9,635,000
Israel	196	574,000	302	586,000
Japan	1,103	1,492,000	391	421,000
Venezuela	380	1,030,000	188	411,000
United Kingdom	151	337,000	25	76,000
Belgium and Luxembourg	49	82,000	23	49,000
Bolivia	—	—	12	47,000
Other Countries	435	929,000	39	83,000
Total	10,661	20,245,000	6,366	11,308,000
Copper alloy pipe and tubing				
United States	2,065	4,289,000	1,351	2,499,000
Taiwan	46	103,000	95	291,000
India	31	82,000	57	208,000
United Kingdom	91	213,000	52	108,000
Israel	114	294,000	42	98,000
Venezuela	6	18,000	29	81,000
New Zealand	125	375,000	20	58,000
Other Countries	187	589,000	65	209,000
Total	2,665	5,963,000	1,711	3,552,000
Copper alloy wire and cable, not insulated				
United States	573	660,000	252	245,000
South Africa	5	17,000	45	139,000
Colombia	51	120,000	50	86,000
New Zealand	16	50,000	10	31,000
Other Countries	67	173,000	12	50,000
Total	712	1,020,000	369	551,000
Copper alloy fabricated materials, nes				
United States	934	2,352,000	633	1,166,000
United Kingdom	164	384,000	165	303,000
Israel	—	—	40	90,000
Thailand	—	—	52	70,000
Venezuela	—	—	17	39,000
Other Countries	971	2,307,000	43	88,000
Total	2,069	5,043,000	950	1,756,000
Wire and cable insulated[2],				
United States	7,161	15,327,000	4,800	10,503,000
Iran	2	6,000	2,365	5,446,000
Dominican Republic	1,331	2,568,000	620	1,310,000
Cuba	1,282	2,465,000	557	1,263,000
Indonesia	2	4,000	473	1,047,000
Panama	411	849,000	399	955,000
Trinidad-Tobago	13	34,000	480	869,000
Venezuela	83	258,000	309	825,000
Zaire	1	1,000	187	653,000
Pakistan	866	846,000	389	439,000
Bermuda	169	367,000	186	372,000
Philippines	69	183,000	285	359,000
United Kingdom	206	566,000	102	316,000
Other Countries	3,096	6,513,000	1,869	4,573,000
Total	14,692	29,987,000	13,021	28,930,000
Total exports of copper and products		1,327,513,000		835,520,000

Table 1. (concl'd)

	1974		1975[p]	
	(short tons)	($)	(short tons)	($)
Imports				
Copper in ores, concentrates and scrap	54,166	59,523,000	18,210	17,431,000
Copper refinery shapes	24,368	39,283,000	12,024	14,987,000
Copper bars, rods and shapes, nes	1,280	2,208,000	685	1,061,000
Copper plates, sheet strip and flat products	743	1,944,000	293	600,000
Copper pipe and tubing	3,041	7,659,000	3,856	6,691,000
Copper wire and cable, except insulated	682	1,671,000	821	1,904,000
Copper alloy scrap (gross weight)	5,722	6,301,000	4,090	3,408,000
Copper powder	463	1,052,000	313	586,000
Copper alloy refinery shapes, rods and sections	9,743	18,834,000	6,544	10,385,000
Brass plates, sheet and flat products	2,920	6,273,000	2,945	4,972,000
Copper alloy plates, sheet, strip and flat products	1,704	4,470,000	730	2,295,000
Copper alloy pipe and tubing	2,201	6,208,000	2,051	5,367,000
Copper alloy wire and cable, except insulated	678	1,999,000	733	2,055,000
Copper and alloy fabricated material, nes	1,706	4,037,000	1,071	2,822,000
Insulated wire and cable	. .	27,768,000	. .	35,410,000
Copper oxides and hydroxides	364	707,000	188	241,000
Copper sulphate	575	359,000	889	361,000
Copper alloy castings	303	857,000	401	1,001,000
Total imports of copper and products	. .	191,153,000	. .	111,577,000
Consumption[3]				
Refined	273,357	. .	204,142	. .

Source: Statistics Canada.
[1] Blister copper plus recoverable copper in matte and concentrate exported. [2] Includes also small quantities of non-copper wire and cable, insulated. [3] Producers' domestic shipments, refined copper.
[p] Preliminary; — Nil; . . Not available; nes Not elsewhere specified.

The operations of the Icon Sullivan Joint Venture near Chibougamau terminated in June 1975. The mine had been in operation since 1967 and had produced 46,300 tons of copper in concentrate from ore production of 2,346,000 tons.

Joutel Copper Mines Limited also terminated its mining operations in June 1975, due to exhaustion of ore reserves. The mine began to operate in February 1967. It is intended to wind up the company and to distribute the cash proceeds to shareholders.

Ore reserves of Madeleine Mines Ltd. declined in 1975 in spite of additions totalling 421,495 tons during the year. At year-end ore reserves were 3,379,000 tons with an average grade of 1.03 per cent copper.

At the Matagami Quebec Division mine of Mattagami Lake Mines Limited computer control of flotation circuits was begun during 1975. Metallurgical recoveries improved and reagent consumption was reduced substantially.

Ore reserves at the Horne Mine of Noranda Mines Limited were reduced to 231,000 tons with an average grade of 1.05 per cent copper and 0.161 ounces of gold per ton at the end of 1975. It is expected that these reserves will be exhausted and the mine closed during 1976.

Mining operations at the Normetal Mine of Kerr Addison Mines Limited were terminated on April 29, 1975 due to the exhaustion of economic ore reserves.

Table 2. Canada, copper production, trade and consumption, 1966-75

	Production		Exports			Imports	Consumption[2]
	All Forms[1]	Refined	Ore and Matte	Refined	Total	Refined	Refined
	(short tons)						
1966	506,076	433,004	94,888	190,691	285,579	10,492	262,557
1967	613,314	499,846	128,976	275,919	404,895	5,310	219,680
1968	633,313	524,474	161,835	276,619	438,454	5,824	250,104
1969	573,246	449,232	157,816	210,034	367,850	18,137	226,281
1970	672,717	543,727	177,888	292,403	470,291	14,542	237,916
1971	721,430	526,403	225,005	314,901	539,906	21,899	221,053
1972	793,303	546,685	297,409	340,533	637,942	17,902	228,907
1973	908,241	548,488	383,182[r]	318,015[r]	701,197[r]	18,937	254,613
1974	905,417	616,329	379,228	315,164	694,392	24,368	273,357
1975[p]	798,132	583,342	346,760	352,268	699,028	12,024	204,142

Source: Statistics Canada.
[1] Blister copper plus recoverable copper in matte and concentrates exported. [2] Producers' domestic shipments, refined copper.
[p] Preliminary; [r] Revised.

During the producing life of this mine, which began in 1937, a total of 11,143,800 tons of ore was mined yielding 240,140 tons of copper, 570,490 tons of zinc, 174,350 ounces of gold and 14,690,000 ounces of silver.

Metal production at the Chibougamau area properties of Patino Mines (Quebec) Limited (Patino) was seriously affected by a five-month labour strike and by the temporary shutdown of the Copper Cliff, Jaculet and Portage mines due to low metal prices. At the Copper Rand mine, production of ores with a higher-than-average gold content was increased.

The economically recoverable ore reserves of the Poirier mine of Rio Algom Limited were mined out and the mine was permanently closed on June 27, 1975.

Mining at the property of Clinton Copper Mines Ltd. was terminated in June 1975. All plant and equipment were removed from the site.

The Detour Project. This project is a joint venture of Selco Mining Corporation Limited and Pickands Mather & Co. on the Detour copper-zinc-silver discovery in northwestern Quebec. Three mineralized zones had been located up to the end of 1975. Sufficient exploration work was completed in 1975 to indicate a tonnage of 35.4 million tons in one zone and 3.4 million tons in one of the other zones.

Ontario. Copper production at the Sudbury area operations of Falconbridge Nickel was reduced in 1975, compared with 1974, by a 73-day strike by production and maintenance employees, and a subsequent 30 per cent reduction in the operating rate in response to reduced world demand for metals. Four hundred employees were laid off as a result of this reduction. Development of the new Lockerby mine was continued throughout 1975. Sinking of new shafts at the Onaping and Fraser mines and work on the smelter modernization program was temporarily halted in November following the settlement of the strike.

Deliveries of refined copper by Inco in 1975 were 9 per cent below 1974 deliveries. The tonnage and the average copper grade of ore produced were also lower than in 1974. Thirteen of Inco's Ontario mines were in operation during 1975. In the Sudbury area, work began on the development of a new mine, Levack East, with production expected in 1984. Production at the Victoria mine was temporarily halted in December 1975, but following redevelopment work, the mine will reopen late in 1976. The Kirkwood mine is expected to close early in 1976 due to ore reserve exhaustion.

Mattabi Mines Limited completed the access decline into the underground mine. New housing, medical and recreational facilities were constructed at Ignace in the Sturgeon Lake area. Paving was completed on the road from the mine site to Ignace. At the Lyon Lake mine, installation of permanent surface facilities was completed and shaft sinking was advanced to a depth of 688 feet.

At the Geco Division of Noranda Mines Limited, copper production was reduced in 1975 relative to 1974 due to a 10 per cent reduction in the operating rate from the beginning of June, and a two-week shutdown of the milling operation in August corresponding to the shutdown of the Valleyfield zinc reduction plant.

The Schumacher mine of Pamour Porcupine Mines, Limited produced a lower tonnage and grade of copper ore in 1975 than in 1974. A shortage of skilled manpower was a factor. Alterations were begun in December to combine the copper and gold sections of the mill to improve efficiency.

Table 3. Principal copper mines in Canada 1975 and (1974)

Company and Location	Mill or Mine Capacity	Grade of Ore Milled: Copper	Zinc	Lead	Nickel	Silver	Gold	Ore Milled	Copper Concentrate Produced	Grade of Copper in Concentrate	Contained[1] Copper Produced	Destination[2] of Copper Concentrates
	(tons ore/day)	(%)	(%)	(%)	(%)	(oz/ton)	(oz/ton)	(tons)	(tons)	(%)	(tons)	
Newfoundland												
ASARCO Incorporated, Buchans	1,250	0.95	10.54	5.92	–	3.03	.022	232,000	4,801	26.91	2,040	8
	(1,250)	(1.01)	(11.24)	(6.28)	(–)	(3.25)	(.024)	(264,000)	(5,563)	(26.67)	(2,399)	(10)
Consolidated Rambler Mines Limited, Ming Mine,	1,200	3.20	–	–	–	0.57	.06	224,562	29,691	23.8	7,072	1
	(1,200)	(3.16)	(–)	(–)	(–)	(0.57)	(.06)	(183,201)	(23,330)	(24.0)	(5,356)	(1,2)
East Mine, Baie Verte	–	–	–	–	–	–	–	–	–	–	–	–
	(–)	(1.38)	(–)	(–)	(–)	(–)	(–)	(32,340)	(1,798)	(24.0)	(414)	(1,2)
New Brunswick												
Brunswick Mining and Smelting Corporation Limited, No. 6 and No. 12 mines, Bathurst	10,000	0.40	7.11	2.95	–	2.33	–	3,427,239	27,786	20.23	5,260	1
	(10,000)	(0.38)	(6.70)	(2.96)	(–)	(2.32)	(–)	(2,607,965)	(20,329)	(20.07)	(3,815)	(1)
Heath Steele Mines Limited, Newcastle	3,100	1.03	3.99	1.54	–	1.73	0.018	1,089,443	28,074	22.28	7,447	1
	(3,100)	(1.04)	(4.39)	(1.72)	(–)	(1.98)	(0.018)	(1,085,495)	(26,766)	(23.34)	(7,243)	(1,2)
Nigadoo River Mines Limited, Robertville	1,000	0.25	2.69	2.55	–	3.44	–	255,078	1,201	20.62	521	8
	(1,000)	(0.33)	(2.74)	(2.53)	(–)	(3.74)	(–)	(205,691)	(1,332)	(20.11)	(268)	NS
Anaconda Canada Limited, Caribou Mine, Restigouche County	–	–	–	–	–	–	–	–	–	–	–	–
	(700)	(3.76)	(3.95)	(1.86)	(–)	(2.30)	(0.02)	(163,432)	(20,384)	(11.23)	(2,044)	(8)

Quebec												
Bouzan Joint Venture, Patino Mines (Quebec) Limited, Kerr Addison Mines Limited, Chibougamau	— (—)	— (1.72)	— (—)	— (. .)	— (—)	— (—)	— (. .)	— (1,550)	— (. .)	— (. .)	— (. .)	— (. .)
Campbell Chibougamau Mines Ltd., Main, Cedar Bay, Henderson, Grandroy and Gwillim mines, Chibougamau	4,000 (4,000)	1.31 (1.03)	— (—)	— (—)	— (—)	0.229 (0.22)	.054 (.025)	219,543 (960,552)	9,193 (35,566)	24.08 (25.66)	2,214 (9,125)	2 (2)
Falconbridge Copper Limited, Lake Dufault Division, Norbec and Millenbach mines, Noranda	1,550 (1,500)	2.50 (2.38)	3.35 (3.54)	— (—)	— (—)	1.12 (0.99)	.023 (.019)	560,775 (553,187)	49,810 (46,470)	26.38 (26.17)	13,084 (11,615)	2 (2)
Opemiska Division, Perry and Springer mines, Chapais	3,000 (3,000)	2.02 (1.85)	— (—)	— (—)	— (—)	0.33 (0.32)	0.014 (0.012)	952,000 (927,059)	76,000 (66,643)	. . (. .)	18,500 (16,374)	2 (2)
Gaspé Copper Mines, Limited, Needle Mountain and Copper Mountain mines, Murdochville	33,750 (33,750)	0.52 (0.61)	— (—)	— (—)	— (—)	0.12 (0.05)	0.002 (0.002)	10,993,105 (10,630,690)	205,258 (202,854)	23.69 (25.31)	46,493 (48,245)	1 (1,2)
Icon Sullivan Joint Venture, Chibougamau	600 (650)	3.26 (3.05)	— (—)	— (—)	— (—)	. . (—)	0.017 (. .)	40,248 (199,500)	4,683 (. .)	26.95 (. .)	1,262 (5,883)	2 (. .)
Joutel Copper Mines Limited, Joutel	— (700)	1.80 (1.79)	— (—)	— (—)	— (—)	— (—)	. . (. .)	3,699 (58,298)	. . (3,788)	25.84 (26.08)	94 (877)	2 (2)

Table 3. (cont'd)

Company and Location	Mill or Mine Capacity	Grade of Ore Milled Copper	Zinc	Lead	Nickel	Silver	Gold	Ore Milled	Copper Concentrate Produced	Grade of Copper in Concentrate	Contained[1] Copper Produced	Destination[2] of Copper Concentrates
	(tons ore/day)	(%)	(%)	(%)	(%)	(oz/ton)	(oz/ton)	(tons)	(tons)	(%)	(tons)	
Quebec (cont'd)												
La Société minière Louvem inc, Louvicourt	— (500)	— (1.95)	— (—)	— (—)	— (—)	— (0.958)	— (0.007)	150,468 (158,183)	— (12,199)	— (23.93)	— (2,920)	— (2)
Madeleine Mines Ltd., St. Anne des Monts	2,500 (2,500)	1.148 (1.27)	— (—)	— (—)	— (—)	0.20 (0.22)	— (—)	908,225 (804,390)	29,168 (30,049)	33.178 (31.61)	9,677 (9,499)	1 (1)
Manitou-Barvue Mines Limited, Val d'Or	1,600 (1,600)	— (—)	1.88 (2.20)	0.30 (0.35)	— (—)	2.39 (2.58)	0.018 (0.017)	244,994 (225,303)	— (—)	— (—)	19 (25)	. . (. .)
Mattagami Lake Mines Limited, Matagami	3,850 (3,850)	0.62 (0.62)	7.3 (7.5)	— (—)	— (—)	0.86 (0.88)	0.014 (0.017)	1,285,703 (1,406,265)	24,882 (27,148)	24.11 (24.38)	6,778 (6,619)	2 (2)
Noranda Mines Limited, Horne Division	2,100 (2,200)	2.15 (2.80)	— (—)	— (—)	— (—)	— (0.59)	0.135 (0.158)	344,300 (390,000)	96,700 (71,500)	25.91 (14.00)	25,066 (10,248)	2 (2)
Normetal Mines Limited, Normetal	1,000 (1,000)	0.58 (0.97)	5.86 (4.58)	— (—)	— (—)	1.28 (1.1)	0.015 (0.016)	82,150 (250,492)	1,739 (8,245)	23.07 (25.60)	391 (2,004)	2 (2)
Orchan Mines Limited, Orchan and Garon Lake mines, Matagami	1,900 (1,900)	1.19 (1.18)	4.65 (4.78)	— (0.05)	— (—)	0.48 (0.50)	0.009 (0.012)	421,805 (364,030)	16,727 (14,053)	25.53 (25.30)	4,271 (3,556)	2 (2)

Patino Mines (Quebec) Limited Copper Rand, Copper Cliff and Portage mines, Chibougamau	1,700 (2,800)	1.67 (1.56)	— (—)	— (—)	— (—)	0.25 (0.20)	0.057 (0.043)	439,515 (859,332)	28,100 (51,777)	24.91 (24.63)	7,009 (12,755)	2 (2)
Rio Algom Limited, Mines de Poirier, Joutel	1,800 (1,800)	2.43 (2.06)	. — (—)	— (—)	— (—)	. . (1.8)	. . (—)	220,757 (437,053)	19.391 (32,260)	26.24 (26.25)	5,083 (8,046)	2 (2)
Sullivan Mining Group Ltd., Stratford Centre Cupra Division	1,400 (1,500)	2.24 (2.49)	4.12 (4.78)	0.47 (0.59)	— (—)	0.972 (1.112)	0.013 (0.014)	56,058 (87,474)	4,182 (7,804)	28.08 (26.04)	1,187 (2,054)	10,11 (9,10,11)
D'Estrie Mining Company Ltd.	— —	2.57 (2.56)	2.12 (2.72)	0.54 (0.61)	— (—)	1.116 (1.155)	0.015 (0.015)	180,094 (162,081)	15,369 (14,719)	28.06 (26.33)	4,359 (3,916)	10,11 (9,10,11)
Clinton Copper Mines Ltd.	— (—)	2.59 (2.64)	2.49 (2.50)	0.47 (0.48)	— (—)	0.876 (0.951)	0.013 (0.012)	73,535 (52,656)	7,127 (5,606)	24.10 (22.68)	1,728 (1,282)	10,11 (9,10,11)
Ontario												
Consolidated Canadian Faraday Limited, Werner Lake	1,200 (1,200)	— (0.30)	— (—)	— (—)	— (0.72)	— (—)	— (—)	— (326,378)	— (—)	— (—)	— (753)	— (4)
Falconbridge Nickel Mines Limited, East, Falconbridge, Fecunis, Hardy, Openpit, Longvac South, North, Onaping and Strathcona mines, Sudbury	12,300 (12,300)	. . (. .)	. . (. .)	— (—)	. . (. .)	. . (. .)	. . (. .)	3,012,005 (4,336,652)	. . (. .)	. . (. .)	20,357[12] (26,991)[12]	4 (4)
Falconbridge Copper Limited, Sturgeon Lake Joint Venture Sturgeon Lake	1,200 (1,200)	2.78 (2.05)	9.07 (7.59)	1.17 (1.09)	— (—)	5.31 (. .)	0.018 (. .)	376,682 (82,592)	31,333 (4,486)	24.58 (21.70)	7,701 (973)	2 (2)

Table 3. (cont'd)

Company and Location	Mill or Mine Capacity	Grade of Ore Milled: Copper	Zinc	Lead	Nickel	Silver	Gold	Ore Milled	Copper Concentrate Produced	Grade of Copper in Concentrate	Contained[1] Copper Produced	Destination[2] of Copper Concentrates
	(tons ore/day)	(%)	(%)	(%)	(%)	(oz/ton)	(oz/ton)	(tons)	(tons)	(%)	(tons)	
Ontario (cont'd)												
Inco, Clarabelle, Coleman, Copper Cliff North, Copper Cliff South, Creighton, Frood-Stobie, Garson, Kirkwood, Levack, Little Stobie, MacLennan, Victoria and Crean Hill mines, Sudbury Shebandowan Mine, Shebandowan	68,000 (68,000)	1.09 (1.15)	— (—)	— (—)	1.29 (1.30)	. . (. .)	. . (. .)	17,188,964 (18,021,305)	. . (. .)	. . (. .)	167,275[3] (183,600)[3]	3 (3)
Kanichee Mining Incorporated, Temagami	500 (500)	0.72 (0.72)	— (—)	— (—)	0.50 (0.49)	— (—)	— (—)	150,066 (122,451)	11,348 (6,979)	7.98 (8.86)	906 (619)	4 (4)
Mattabi Mines Limited, Sturgeon Lake	3,000 (3,000)	0.97 (0.91)	7.34 (8.81)	0.70 (0.91)	— (—)	3.23 (4.31)	— (—)	1,074,923 (1,138,965)	37,000 (33,900)	23.52 (25.43)	8,647 (8,708)	2 (2)
Noranda Mines Limited, Geco Division, Manitouwadge	5,000 (5,000)	1.84 (1.72)	3.54 (4.72)	0.20 (0.20)	— (—)	1.44 (1.56)	— (—)	1,599,333 (1,826,704)	102,534 (111,800)	26.69 (25.90)	28,132 (29,669)	2 (2)
Pamour Porcupine Mines, Limited, Schumacher Division, Schumacher	3,000 (3,000)	0.62 (0.63)	— (—)	— (—)	— (—)	0.11 (0.11)	0.027 (0.023)	684,680 (706,940)	12,860 (15,191)	30.33 (. .)	3,900 (4,084)	2 (2)

Selco Mining Corporation Limited, South Bay Division, Uchi Lake	500 (500)	1.82 (2.00)	11.18 (11.96)	— (—)	— (—)	2.73 (3.00)	— (—)	168,334 (195,000)	10,277 (12,212)	26.32 (25.64)	2,705 (3,060)	2 (2)
Teck Corporation Limited, Silverfields Mining Division, Cobalt District	275 (275)	0.4 (0.4)	— (—)	— (—)	— (—)	9.7 (12.5)	— (—)	48,411 (87,891)	. . (. .)	5.3 (5.0)	4 (34)	2 (2)
Texasgulf Inc., Kidd Creek Mine, Timmins	10,000 (10,000)	1.71 (1.75)	8.20 (9.20)	0.25 (0.30)	— (—)	3.10 (3.17)	— (—)	3,630,224 (3,723,865)	238,456 (241,188)	23.35 (23.96)	59,656 (56,649)	2 (2)
Willroy Mines Limited, Manitouwadge Division, Manitouwadge	1,400 (1,700)	0.42 (0.42)	3.82 (3.06)	0.22 (0.23)	— (—)	1.56 (1.37)	— (—)	327,353 (394,154)	4,315 (. .)	24.79 (25.68)	1,070 (1,375)	2 (2)
Manitoba												
Dumbarton Mines Limited,												
Maskwa East Extension,	—	0.37	—	—	0.82	—	—	53,464	—	—	170	11
Maskwa West Extension,	—	0.22	—	—	1.16	—	—	303,246	—	—	542	11
Bird River	(—)	(0.30)	(—)	(—)	(0.72)	(—)	(—)	(326,378)	(—)	(—)	(881)	(11)
Falconbridge Nickel Mines Limited, Manibridge mine, Wabowden	1,000 (1,000)	. . (. .)	— (—)	— (—)	. . (. .)	. . (. .)	— (—)	188,797 (183,758)	. . (. .)	. . (. .)	. .[4] (. .)[4]	3,4 (3,4)
Hudson Bay Mining and Smelting Co., Limited, Anderson, Chisel Lake, Dickstone, Flin Flon, Ghost, Osborne, Schist, Stall Lake, White Lake and Centennial mines, Flin Flon and Snow Lake	8,500 (8,500)	2.40 (2.34)	3.00 (3.22)	0.20 (0.12)	— (—)	0.60 (0.63)	0.030 (0.035)	1,470,157 (1,574,948)	198,308 (215,076)	16.48 (16.02)	33,179 (35,030)	6 (6)

Table 3. (cont'd)

Company and Location	Mill or Mine Capacity	Grade of Ore Milled Copper	Zinc	Lead	Nickel	Silver	Gold	Ore Milled	Copper Concentrate Produced	Grade of Copper in Concentrate	Contained[1] Copper Produced	Destination[2] of Copper Concentrates
	(tons ore/day)	(%)	(%)	(%)	(%)	(oz/ton)	(oz/ton)	(tons)	(tons)	(%)	(tons)	
Manitoba (cont'd)												
Inco,												
Birchtree, Pipe and Thompson mines, Thompson	18,400 (17,700)	. . (. .)	— (—)	— (—)	. . (. .)	— (—)	— (—)	3,767,390 (3,767,202)	. . (. .)	. . (. .)	. .[5] (. .)[5]	3 (3)
Sherritt Gordon Mines Limited,												
Farley mine, Lynn Lake	4,000 (3,000)	0.38 (0.43)	— (—)	— (—)	0.84 (0.87)	— (—)	— (—)	351,536 (432,235)	1,958 (3,326)	30.24 (30.72)	1,133 (1,625)	6 (6,7)
Fox mine, Lynn Lake	2,840 (3,000)	1.74 (2.10)	1.81 (1.98)	— (—)	— (—)	. . (0.33)	. . (. .)	1,007,183 (1,008,111)	65,834 (82,079)	23.92 (23.90)	16,000 (19,850)	6,9 (6,9)
Ruttan mine, Ruttan Lake	10,000 (10,000)	0.96 (1.07)	1.90 (1.68)	— (—)	— (—)	. . (0.20)	. . (0.007)	3,340,794 (3,358,257)	114,341 (130,781)	24.02 (23.68)	28,427 (31,833)	2 (6,2)
British Columbia												
Bethlehem Copper Corporation, Heustis mine, Highland Valley	20,000 (16,000)	0.474 (0.51)	— (—)	— (—)	— (—)	0.02 (—)	. . (. .)	6,464,539 (6,346,402)	82,641 (85,648)	33.05 (33.13)	27,315 (29,319)	9 (9)
Brenda Mines Ltd., Peachland	24,000 (24,000)	0.188 (0.19)	— (—)	— (—)	— (—)	. . (. .)	. . (. .)	10,048,545 (9,549,588)	57,667 (51,365)	28.87 (29.74)	16,646 (15,267)	8,9,2 (9)
Consolidated Churchill Copper Corporation Ltd., Magnum mine, Fort Nelson	900 (900)	3.51 (—)	— (—)	— (—)	— (—)	. . (. .)	. . (. .)	48,936 (201,450)	5,480 (. .)	30.49 (. .)	1,670 (5,320)	. . (. .)
Craigmont Mines Limited, Merritt	5,300 (5,350)	1.45 (1.45)	— (—)	— (—)	— (—)	— (—)	— (—)	1,956,316 (1,796,692)	92,784 (87,014)	29.39 (28.95)	27,265 (25,775)	8,9,3 (8,9,11)

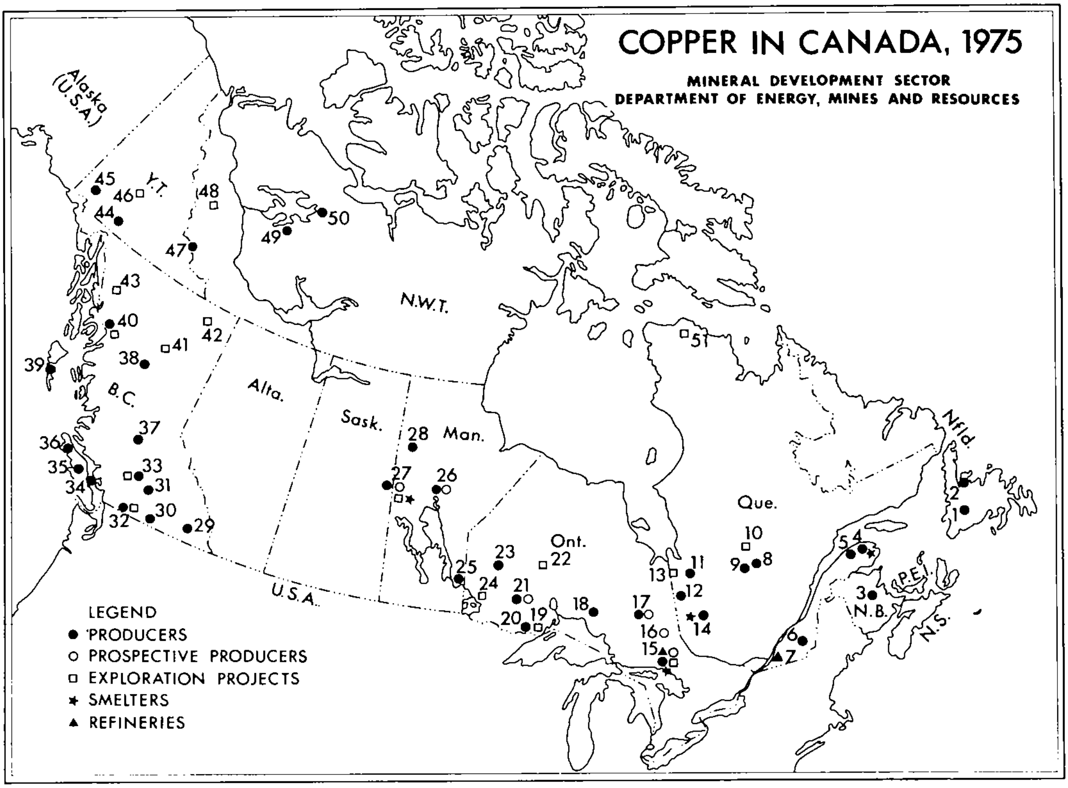
Falconbridge Nickel Mines Ltd.,												
Wesfrob Mines	5,800	0.212	—	—	—	—	—	1,788,383	8,862	19.60	1,700	9
Limited,	(5,800)	(0.282)	(—)	(—)	(—)	(—)	(—)	(939,313)	(11,069)	(20.72)	(2,172)	(9)
Tasu mine, Tasu Harbour, Q.C.I.												
Gibraltar Mines Ltd.,												
(N.P.L.),	40,000	0.431	—	—	—	—	—	11,450,000	158,779	26.31	41,780	9
McLeese Lake,	(40,000)	(0.40)	(—)	(—)	(—)	(—)	(—)	(13,397,264)	(166,780)	(27.06)	(45,123)	(9)
Caribou District												
Granby Mining Corporation,												
Granisle mine,	13,000	0.436	—	—	—	0.038	0.039	4,932,982	. .	. .	19,694	9,10
Babine Lake	(13,000)	(0.446)	(—)	(—)	(—)	(. .)	(. .)	(4,780,857)	(59,439)	(32.13)	(19,100)	(9,10)
Phoenix Copper												
Division,	2,800	0.487	—	—	—	0.175	.017	1,086,747	17,274	. .	4,631	8
Greenwood	(2,750)	(0.446)	(—)	(—)	(—)	(0.134)	(.017)	(1,012,426)	(14,320)	(26.61)	(3,666)	(9)
Granduc Operating												
Company,	7,500	1.20	—	—	—	. .	. .	1,653,000	65,303	28.58	18,668	8,9
Granduc mine,	(8,000)	(1.23)	(—)	(—)	(—)	(0.216)	(0.004)	(2,708,731)	(113,408)	(28.11)	(31,879)	(9)
Stewart												
Lornex Mining Corporation Ltd.,												
Lornex mine,	45,000	0.495	—	—	—	. .	. .	12,893,157	170,052	32.66	53,575	8,9
Highland Valley	(45,000)	(0.457)	(—)	(—)	(—)	(. .)	(. .)	(16,455,460)	(210,071)	(31.59)	(51,996)	(9)
Noranda Mines Limited,												
Bell Copper	13,000	0.456	—	—	—	. .	. .	4,778,598	69,758	26.02	18,150	2
Division,	(10,000)	(0.524)	(—)	(—)	(—)	(. .)	(. .)	(4,500,998)	(78,952)	(26.10)	(19,817)	(2,9)
Babine Lake												
Similkameen Mining												
Company Limited,	15,000	0.46	—	—	—	0.02	. .	4,072,000	58,936	27.6	16,270	8,9
Ingerbelle Pit,	(15,000)	(0.48)	(—)	(—)	(—)	(—)	(. .)	(5,086,000)	(78,960)	(26.7)	(21,000)	(8,9)
Princeton												
Texada Mines Ltd.,	4,000	0.293	—	—	—	0.049	.0014	1,025,132	9,138	21.51	1,768	9
Vanada	(4,500)	(0.292)	(—)	(—)	(—)	(0.049)	(.0014)	(925,000)	(7,562)	(21.50)	(1,398)	(9)

Table 3. (concl'd)

Company and Location	Mill or Mine Capacity	Grade of Ore Milled: Copper	Zinc	Lead	Nickel	Silver	Gold	Ore Milled	Copper Concentrate Produced	Grade of Copper in Concentrate	Contained[1] Copper Produced	Destination[2] of Copper Concentrates
	(tons ore/day)	(%)	(%)	(%)	(%)	(oz/ton)	(oz/ton)	(tons)	(tons)	(%)	(tons)	
British Columbia (cont'd)												
Utah Mines Ltd., Island Copper Mine, Coal Harbour V.I.	38,000 (38,000)	0.48 (0.47)	— (—)	— (—)	— (—)	. . (. .)	. . (. .)	13,300,000 (11,200,000)	233,000 (191,000)	24.0 (24.0)	55,379 (43,850)	9 (9)
Western Mines Limited, Lynx and Myra Mines, Buttle Lake V.I.	1,100 (1,100)	1.12 (1.28)	7.59 (8.05)	1.42 (1.48)	— (—)	4.49 (4.52)	0.08 (0.09)	287,393 (297,290)	8,877 (10,320)	28.30 (27.66)	2,989 (3,521)	9 (9)
Yukon Territory												
Whitehorse Copper Mines Ltd., Little Chief Mine, Whitehorse	2,400 (2,000)	1.52 (1.84)	— (—)	— (—)	— (—)	. . (0.346)	. . (.028)	738,062 (618,000)	27,648 (27,848)	36.16 (36.00)	10,031 (10,406)	6 (2)
Northwest Territories,												
Canada Tungsten Mining Corporation Limited, Tungsten	575 (600)	0.23 (0.17)	— (—)	— (—)	— (—)	— (—)	— (—)	179,032 (170,614)	— (414)	— (19.77)	— (82)	— (9)
Echo Bay Mines Ltd., Port Radium	150 (150)	. . (0.99)	— (—)	— (—)	— (—)	. . (104.29)	— (—)	31,251 (20,768)	2,170 (1,402)	17.70 (14.05)	399 (215)	8 (. .)
Terra Mining and Exploration Ltd., Camsell River Mine, Great Slave Lake	175 (175)	. . (0.30)	— (—)	— (—)	— (—)	. . (24.02)	— (—)	42,881 (45,684)	. . (. .)	. . (. .)	54 (238)	. . (8,11)

Sources: Company reports and technical press.
[1]Total copper in concentrates. [2]Destination of concentrates: 1, Gaspé Copper Mines Limited; 2, Noranda Mines Limited; 3, Inco, Sudbury; 4, Falconbridge Nickel, Sudbury; 5, Falconbridge Nickel, Norway; 6, Hudson Bay Mining and Smelting Co. Ltd.; 7, Sherritt Gordon Mines Ltd.; 8, United States; 9, Japan; 10, Germany; 11, Unspecified and other countries. [3]Derived from deliveries not reported directly. [4]Included in the Sudbury total for Falconbridge Nickel Mines Limited. [5]Included in the Copper Cliff total for Inco.

NS None sold; — Nil; . . Not available



Producers

(numbers correspond to those on the map)

1. ASARCO Incorporated
2. Consolidated Rambler Mines Limited
3. Brunswick Mining and Smelting Corporation Limited (No. 6 and No. 12 mines)
   Heath Steele Mines Limited
   Nigadoo River Mines Limited
4. Gaspé Copper Mines, Limited
5. Madeleine Mines Ltd.
6. Sullivan Mining Group Ltd. (Cupra, d'Estrie, Clinton Mines)
   Bouzan Joint Venture
8. Campbell Chibougamau Mines Ltd. (Cedar Bay, Henderson, Main, Grandroy, Gwillim mines)
   Icon Sullivan Joint Venture
   Patino Mines (Quebec) Limited (Copper Rand, Copper Cliff, Portage mines)
9. Falconbridge Copper Limited, Opemiska Division (Perry, Springer, Cooke mines)
11. Joutel Copper Mines Limited
   Mattagami Lake Mines Limited
   Orchan Mines Limited (Orchan, Garon Lake mines)
12. Normetal Mines Limited
14. Falconbridge Copper Limited, Lake Dufault Division (Norbec, Millenbach mines)
   Noranda Mines Limited (Horne Mine)
15. Falconbridge Nickel Mines Limited (East, Falconbridge, Fecunis, Hardy, Longvack South, North, Onaping, Strathcona mines)
   The International Nickel Company of Canada, Limited (Inco) (Clarabelle, Coleman, Copper Cliff North, Copper Cliff South, Creighton, Frood Stobie, Garson, Kirkwood, Levack, Little Stobie, MacLennan, Victoria, Crean Hill Mines)
16. Kanichee Mining Incorporated
17. Texasgulf Inc. (Kidd Creek mine)
   Pamour Porcupine Mines, Limited
18. Noranda Mines Limited, Geco Division
   Willroy Mines Limited (Willecho, Willroy mines)
20. Inco (Shebandowan)
21. Sturgeon Lake Mines Limited
   Mattabi Mines Limited
23. Selco Mining Corporation Limited, South Bay Division
25. Dumbarton Mines Limited

Producers (concl'd)

26. Falconbridge Nickel Mines Limited (Manibridge mine)
Inco (Birchtree, Pipe and Thompson mines)
27. Hudson Bay Mining and Smelting Co., Limited
(Centennial mine, Anderson, Chisel, Dickstone, Flin Flon, Ghost, Osborne, Schist, Stall, White Lake mines)
28. Sherritt Gordon Mines Limited (Farley, Fox and Ruttan mines)
30. Granby Mining Corporation, Phoenix Copper Division
31. Brenda Mines Ltd.
32. Similkameen Mining Company Limited (Ingerbelle and Similkameen deposits)
33. Bethlehem Copper Corporation (Huestis, Iona and Jersey mines)
Lornex Mining Corporation Ltd.
Craigmont Mines Limited
34. Texada Mines Ltd.
35. Western Mines Limited (Lynx, Myra mines)
36. Utah Mines Ltd. (Island Copper mine)
37. Gibraltar Mines Ltd.
38. Granby Mining Corporation (Granisle mine)
Noranda Mines Limited, Bell Copper Division
39. Falconbridge Nickel Mines Limited (Wesfrob mine)
40. Granduc Operating Company
42. Consolidated Churchill Copper Corporation Ltd.
44. Whitehorse Copper Mines Ltd. (Little Chief mine)
47. Canada Tungsten Mining Corporation Limited
49. Terra Mining and Exploration Limited
50. Echo Bay Mines Ltd.

Prospective producers

3. Brunswick Mining and Smelting Corporation Limited (No. 12 mine)
Heath Steele Mines Limited (Little River Mine)
8. Patino Mines (Quebec) Limited (Lemoine ML, Jaculet)
11. Orchan Mines Limited (Norita mine)
15. Falconbridge Nickel Mines Limited (Lockerby, Thayer Lindsay mine)
Inco (Murray, Totten, Levack East, Victoria)
17. Texasgulf Inc. (Kidd Creek No. 2 mine)
22. Union Minière Explorations and Mining Corporation Limited (Thierry mine)
26. Inco (Soab, Birchtree mines)
27. Hudson Bay Mining and Smelting Co., Limited (Centennial, Westarm mines)
33. Afton Mines Ltd. (Kamloops)

Exploration projects

51. New Quebec Raglan Mines Limited
10. Selco Mining Corporation Limited and Muscocho Explorations Limited
11. Phelps Dodge Corporation of Canada, Limited
13. Selco Mining Corporation/Moore McCormack Resources Inc. (Detour Project)
14. Copperfields Mining Corporation and Iso Mines Limited
New Insco Mines Ltd. and others
Falconbridge Copper Limited (Lake Dufault Division)
Noranda Mines Limited (Magusi River property)
15. Falconbridge Nickel Mines Limited (Fraser, Craig, Onex mines)
Inco (Cryderman, Whistle mine)
19. Great Lakes Nickel Limited
27. Hudson Bay Mining and Smelting Co., Limited
(Hudvam, Rail, Reed, Wim mines, Lost Lake deposit)
Stall Lake Mines Limited
Freeport Canadian Exploration Company and Beth-Canada Mining Company (Reed Lake property)
32. Adonis Mines Ltd.
Giant Mascot Mines Limited (Giant Copper (Canada) mine)
33. Bethlehem Copper Corporation (J-A, Maggie, Lake and Iona zones)
Highmont Mining Corp. Ltd.
Leemac Mines Ltd.
Valley Copper Mines Limited
40. Consolidated Citex Resources Inc.
41. Falconbridge Nickel Mines Limited (Sustut deposit)
42. Davis-Keays Mining Co. Ltd.
43. Liard Copper Mines Ltd.
Stikine Copper Limited
46. Silver Standard Mines Limited and Asarco Exploration Company of Canada, Limited
United Keno Hill Mines Limited — Falconbridge
Nickel Mines Limited — Canadian Superior Exploration Limited
48. Shell Canada Limited (Coates Lake)

Smelters

4. Gaspé Copper Mines, Limited
14. Noranda Mines Limited
15. Falconbridge Nickel Mines Limited
Inco
27. Hudson Bay Mining and Smelting Co., Limited

Refineries

7. Canadian Copper Refiners Limited
15. Inco

Selco Mining Corporation Limited reported an increase in ore reserves at the end of March 1976 to 787,725 tons with an average grade of 1.52 per cent copper, 10.10 per cent zinc, and 2.03 ounces of silver a ton. This is the highest reserve position ever reported for the mine. Shaft sinking reached a depth of 1,825 feet and was halted at that level to permit mining of the new No. 12 ore zone.

Falconbridge Copper, Sturgeon Lake Mines Limited (SLM) and NBU Mines Limited (NBU) are the partners in Sturgeon Lake Joint Venture (SLJV). SLJV has built a facility to mine a copper-zinc deposit at Sturgeon Lake, Ontario. Falconbridge Copper provided 93.4 per cent of the total financing, which amounted to $19 million and manages the operation. Falconbridge Copper and NBU will recoup their expenditures out of the earnings of SLJV. The mine, an open-pit operation, began commercial operation on February 1, 1975. After mining of 434,000 tons in 1975, ore reserves at the end of the year were estimated to be 1,804,000 tons with an average grade of 2.85 per cent copper, 10.28 per cent zinc, 1.36 per cent lead, 5.66 ounces of silver and 0.022 ounce of gold a ton.

At the Kidd Creek mine of Texasgulf Inc. production continued in both the open-pit and the underground mine. About 2.27 million tons of ore were mined from the open-pit and 1.36 million tons from underground. Mining in the open-pit is expected to terminate at the end of 1976, to be offset by increased production from underground. Backfilling of mined-out stopes will begin in mid-1976. A second underground mine will increase ore production from 3.6 to 5 million tons of ore a year. Shaft development at the No. 2 mine began in 1975 with completion of a pilot borehole to the 2,800-foot level and enlargement of this opening up to the 2,600-foot level. Construction of surface facilities for the No. 2 mine began during 1975. The Hoyle concentrator will be expanded to handle the increased ore production. This expansion will be timed to provide feed for the new copper smelter and refinery which is scheduled to start up late in 1978. Proven and probable ore reserves at the end of 1975 at the mine, above the 2,800-foot level, were estimated to be 86 million tons with an average grade of 2.70 per cent copper, 0.21 per cent lead, 5.92 per cent zinc and 2.31 ounces of silver a ton.

The Thierry Project. Union Minière Explorations and Mining Corporation Limited stated in July 1975 that it now expects to spend $85 million to develop its Thierry copper deposit in the Pickle Crow district of northwestern Ontario. The cost of the project was estimated to be $45 million in 1972. Production is scheduled to begin in mid-1976. The mine will have the capacity to produce 1,375,000 tons a year of ore, containing approximately 20,000 tons of recoverable copper.

Manitoba. Hudson Bay Mining and Smelting Co., Limited operated eight mines in the Flin Flon-Snow Lake area in 1975. The Dickstone mine was closed temporarily in August due to depressed economic conditions. The Schist Lake and White Lake mines are expected to be closed in 1976 due to exhaustion of economic ore reserves. At the Centennial mine, the main shaft was sunk to a depth of 1,411 feet. Lateral development was started on most levels during the year. At the Westarm mine surface facilities were installed and the shaft had been sunk to a depth of 1,457 feet by year-end.

The Lynn Lake mine of Sherritt Gordon Mines Limited (Sherritt) was operated on a salvage basis during 1975. As a result of a shortage of miners, Sherritt contracted the underground operation out to another company in November.

At Sherritt's Fox mine recoverable ore reserves were estimated at the end of 1975 to be 8.7 million tons with an average grade of 1.92 per cent copper and 2.08 per cent zinc. The mine will be placed on a five-day week in 1976 to allow a transfer of personnel to the Ruttan mine to assist in the underground development of the deeper ore of this mine.

At the Ruttan mine low equipment availability, failure to achieve scheduled stripping rates and resulting temporary loss of access to higher-grade parts of the open-pit orebody resulted in reduced copper production in 1975. In December 1975 the planned production rate was reduced by 20 per cent to 2.8 million tons of ore a year. Development of the underground mine at Ruttan also lagged behind schedule in 1975. The access decline reached the 1,200 foot level shortly after year-end. Extensive underground exploration was scheduled for 1976.

British Columbia. Copper production at the Highland Valley operations of Bethlehem Copper Corporation (Bethlehem) declined to 54.6 million pounds in 1975 compared with 57.1 million pounds in 1974. The average grade of ore mined dropped by 8 per cent but this was partly offset by an increase in the milling rate. Unit costs were reduced by a deferral of waste removal pending an increase in copper prices. Five new 100-ton haulage trucks were put into operation during the year. Ore reserves at the present operation are sufficient for eight more years at the current production rate. Discussions continued with Valley Copper Mines Limited with the object of developing a mutually satisfactory plan to bring the Lake Zone orebody into production.

Brenda Mines Ltd. (Brenda) achieved higher operating rates during 1975. Average daily mill throughput increased by 1,367 tons of ore a day and copper recovery increased to 87.9 per cent, from 85.9 per cent in 1974. A computer control system was developed for the mill grinding system which will be extended from one, to all four grinding circuits in 1976. Smelting and marketing charges increased sharply in 1975 due to expiry, after the June shipment, of the five-year sales contract for copper concentrate with Japanese smelters, and to the much-higher charges that now prevail to custom smelters in North America.

Table 4. Prospective[1] copper producers

Company and Location	Mill Capacity[2] and Ore Grade	Year Production Expected	Destination of Copper Concentrates	Remarks
New Brunswick				
Brunswick Mining and Smelting Corporation Limited, No. 12 mine, Bathurst	11,000 Cu 0.30 Pb 3.79 Zn 9.22	1979	Murdochville, Noranda	Expanding No. 12 mine to 11,000 tpd from 7,000. Development includes new 26-foot-diameter shaft.
Heath Steele Mines Limited, Little River mine Newcastle	4,000 Cu, Pb, Zn	1977	Murdochville	Sinking new shaft, expanding mill from 3,000 to 4,000 tpd.
Quebec				
Orchan Mines Limited, Norita mine, Matagami	— Cu 0.70 Zn 7.60	1976	Noranda	900 tpd to be trucked to Orchan mill. Mine development almost complete at the end of 1975.
Orchan Mines Limited, La Gauchetiere Township	800 Zn 4.5 Cu 0.9 Ag 0.5 oz	1978	Noranda	Deposit acquired from Phelps Dodge Corporation of Canada. Will be developed by decline and 1,800 ft. vertical shaft.
Patino Mines (Quebec) Limited, Lemoine Mines Limited	400 Cu 4.5 Zn 10.8	1976	Noranda	Plant in tune-up phase, mine development to production stage almost complete at end of 1975.
Ontario				
Texasgulf Inc., Kidd Creek mine, Timmins	14,000 Cu 2.70 Zn 5.92 Pb 0.21 Ag 2.31oz	1978	Timmins	Building a 65,000 tpy copper smelter/refinery by 1978-1979. Mine production to be expanded to 5 million tpy by 1978.
Falconbridge Nickel Mines Limited, Lockerby mine, Falconbridge	2,000 Cu . . Ni . .	1976	Falconbridge	At the end of 1975 the mine had reached an operating rate of 16,000 tons a month, 25 per cent of design capacity
Falconbridge Nickel Mines, Ltd., Thayer Lindsay mine, Falconbridge	— Cu . . Ni . .	. .	Falconbridge	
East mine,	—	. .	Falconbridge	on standby
Onaping mine,	Cu . .	. .	Falconbridge	on standby
Longvack South mine, Sudbury	Ni . .	. .	Falconbridge	on standby
Inco,	—			
Murray mine,	Cu . .	. .	Copper Cliff	on standby
Totten mine,	Ni . .	. .	Copper Cliff	on standby
Levack East,		1984	Copper Cliff	new mine
Victoria, Sudbury		1976	Copper Cliff	Production temporarily halted in December 1975. Will resume following redevelopment.
Union Minière Explorations and Mining Corporation Limited, Thierry	Cu 1.73	1976	Noranda	Production expected in second half of 1976.

Table 4. (concl'd)

Company and Location	Mill Capacity and Ore Grade	Year Production Expected	Destination of Copper Concentrates	Remarks
Manitoba				
Hudson Bay Mining and Smelting Co., Limited, Centennial Mine, Flin Flon	— Cu 2.06 Zn 2.60	1976	Flin Flon	Shaft sunk to 1,411 feet, lateral development started on all levels in 1975.
Westarm Mine, Schist Lake	Cu 4.63	1976	Flin Flon	Shaft sunk to 1,457 feet. Seven level stations excavated in 1975.
Inco, Soab mine, Thompson	— Cu . . Ni . .	. .	Thompson	On standby
Birchtree mine, Thompson	— Cu . . Ni . .	1976	Thompson	Mine deepened and expanded in 1975.
British Columbia				
Afton Mines Ltd., Kamloops	7,000 Cu 1.0	1978	Kamloops	New open pit mine and smelter operation.

Source: Company reports and technical press.
[1]Only mines with announced production plans. [2]Mill capacity in tpd of ore.
— Nil; . . Not available

Table 5. Copper exploration projects

Company and Location	Indicated Ore Tonnage	Grade of Ore	Remarks
	(tons)	(%)	
Quebec			
Selco Mining Corporation Limited and Muscocho Explorations Limited, Frotet Lake	1,463,835	Cu 1.73 Zn 2.96	
Selco Mining Corporation Limited and Pickands Mather (Detour Project) A 1 Zone	35,400,000	Cu 0.39 Zn 2.30 Ag 1.04 oz	Near-surface deposit. Exploration from underground planned in major work program extending to 1978
B Zone	3,375,000	Cu 4.49 Zn 0.80 Ag 1.15	
Broullion Township			

Table 5. (cont'd)

Company and Location	Indicated Ore Tonnage	Grade of Ore	Remarks
	(tons)	(%)	
Noranda Mines Limited, Magusi River property, Noranda	1,569,000	Cu 2.1	Property has an additional tonnage of zinc ore
New Quebec Raglan Mines Limited, Wakeham Bay	16,050,000	Cu 0.71 Ni 2.58	Inactive during 1974.
Ontario			
Falconbridge Nickel Mines Limited,			
Onex shaft,	—	—	Development deferred
Fraser shaft,	—	—	Development reactivated in 1976.
Craig mine,	—	—	Orebody being delineated by drilling in 1975.
Sudbury			
Great Lakes Nickel Limited, Pardee Township	32,800,000	Cu 0.36 Ni 0.20	Mining plans deferred.
Inco,			
Cryderman mine,	—	—	
Whistle mine,	—	—	
Sudbury area			
Manitoba			
Freeport Canadian Exploration Company and Beth-Canada Mining Company, Snow Lake Reed Lake property	1,000,000	Cu 2 Zn 4	Drilling and geo-physicai work in progress
Hudson Bay Mining and Smelting Co., Limited, Flin Flon and Snow Lake,			
Hudvam mine	400,000	Cu 1.50 Zn 1.70	
Lost Lake deposit,	247,000	Cu 1.45	
Rail Lake mine	325,000	Cu 3.00	
Reed Lake mine	1,500,000	Cu 2.09	
Wim mine	1,090,000	Cu 2.91	
Stall Lake Mines Limited, Snow Lake	672,000	Cu 5.38 Zn 2.28	
British Columbia			
Adonis Mines Ltd.,	41,000,000	Cu 0.48	South Zone
Summers Creek,	16,000,000	Cu 0.56	Adit Zone
Princeton	6,400,000	Cu 0.47	West Zone
Bethlehem Copper Corporation,			
J/A zone,	286,280,000	Cu 0.43 Mo 0.017	Proven reserves.
Lake zone,	190,000,000	Cu 0.48	Proven reserves.
Maggie zone,	200,000,000	Cu 0.40	Drill indicated. (Cu equivalent)

Table 5. (concl'd)

Company and Location	Indicated Ore Tonnage	Grade of Ore	Remarks
	(tons)	(%)	
Highland Valley area			
Davis-Keays Mining Co. Ltd., Fort Nelson	1,375,000	Cu 3.38	
Falconbridge Nickel Mines Limited, Sustut Peak	—	Cu 1.25	Amenable to open-pit mining.
Giant Mascot Mines Limited, Giant Nickel Mine, Hope	—	Cu 0.57 Ni 0.96	New ore zone of limited tonnage discovered in 1974.
Highmont Mining Corp. Ltd., Highland Valley	145,000,000	Cu 0.27 MoS_2 0.045	
Leemac Mines Ltd., Trojan property, Highland Valley	. .	Cu 1.56	
Laird Copper Mines Ltd., Schaft Creek	300,000,000	Cu 0.40 MoS_2 0.036	
Noranda Exploration Company, Limited, Gold Stream River	3,500,000	Cu 4.49 Zn 3.24 Ag 0.68	52 miles north of Revelstoke, B.C.
Stikine Copper Limited, Stikine River area	59,000,000 79,000,000	Cu 1.20 Cu 1.00	
Valley Copper Mines Limited, Highland Valley	600,000 tons a vertical foot	Cu 0.48	
Yukon Territory			
Silver Standard Mines Limited and Asarco Exploration Company of Canada, Limited, Minto property, Carmacks	5,200,000	Cu 1.8	Property developed to the feasibility study stage in 1974.
United Keno Hill Mines Limited, Falconbridge Nickel Mines Limited and Canadian Superior Exploration Limited	. .	Cu . .	
Northwest Territories			
Shell Canada Limited Coates Lake	—	Cu . .	High grade copper mineralization has been encountered in exploration drilling.

Sources: Company reports and technical press.
— Nil; . . Not available

Table 6. Canadian copper and copper-nickel smelters, 1975

Company and Location	Product	Rated Annual Capacity	Remarks	Ore and Concentrate Treated	Blister or Anode Copper Produced
		(tons)		(tons)	(tons)
Falconbridge Nickel Mines Limited, Falconbridge, Ontario	Copper-nickel matte	650,000[1]	A smelter modernization program was begun but suspended temporarily during 1975. Fluid-bed roasters and electric furnaces will replace existing smelting equipment and a 1,300-short-tons-a-day sulphuric acid plant will be installed to treat roaster gases. Completion is expected in 1977 or 1978. Refining of copper-nickel matte is carried out in Norway.	. .	. .
Gaspé Copper Mines, Limited, Murdochville, Que.	Copper anodes	370,000[1]	Mine and smelter expansion program was completed but had start-up problems in 1974. As part of the program, a fluid-bed concentrate roaster, a 300,000-tons-a-year sulphuric acid plant and plant water recycling facility were added to facilities previously described. Smelter is fed with Gaspé and custom concentrates and precipitate from copper-leaching operations.	315,800, of which 110,500 were custom concentrates	73,200
Hudson Bay Mining and Smelting Co., Limited, Flin Flon, Manitoba	Blister-copper cakes	575,000[1]	Roasting furnaces, 1 reverberatory furnace, 3 converters. Treats own and custom copper concentrates, along with zinc plant residues, in conjunction with slag-fuming furnaces. A new flue system was completed, including an 825-foot stack.	385,454, of which 130,824 were purchased concentrate	65,742
The International Nickel Company of Canada, Limited, Copper Cliff, Ont.	Blister copper, nickel sulphide and nickel sinter for company's refineries; nickel oxide	4,000,000[1]	Oxygen flask-smelting of copper sulphide concentrate; converters for production of blister copper. Roasters, reverberatory furnaces for smelting of copper-nickel ore and concentrate; converters for production of copper-nickel Bessemer matte. Production of matte followed by matte	. .	. .

	sinter for market. Soluble nickel oxide for market		treatment, flotation, separation of copper and nickel sulphides then by sintering to make sintered-nickel products for refining and marketing. Electric-furnace melting of copper sulphide and conversion of blister copper. Also custom smelting.		
Noranda Mines Limited, Noranda, Que.	Copper anodes	1,700,000[2]	Roasting furnaces, 2 hot-charge and 1 green-charge reverberatory furnaces; 5 converters; 1 continuous reactor. Also smelts custom material. Continuous reactor was modified to produce matte instead of metal. A new 94-ton-a-day oxygen plant was put into operation for oxygen-enriched blast.	1,333,000 (of which 735,000 were custom concentrates)	231,000

Source: Company reports.
[1]Ores and concentrates. [2]Ores, concentrates and scrap.
. . Not available.

Table 7. Copper refineries in Canada, 1975

Company and Location	Rated Annual Capacity	Output	Remarks
	(tons)	(tons)	
Canadian Copper Refiners Limited, Montreal East, Quebec	480,000	395,000	Refines anodes from Noranda and Gaspé smelters, blister copper from Flin Flon smelters, and purchased scrap. Copper sulphate recovered by vacuum evaporation. Precious metals, selenium and tellurium recovered from anode slimes. Produces C.C:R. brand electrolytic copper wirebars, ingot bars, ingots, cathodes, cakes and billets. Start-up of semi-continuous casting of cakes and billets was deferred.
The International Nickel Company of Canada, Limited, Copper Refining Division, Copper Cliff, Ontario.	212,000	167,275[1]	Refines blister copper from Copper Cliff smelter. Precious metals, selenium and tellurium are recovered from anode slimes. Recovers and electrowins copper from Copper Cliff nickel refinery residue. Produces ORC brand electrolytic copper, cathodes, wirebars, cakes, billets, ingots and ingot bars.

Source: Company reports.
[1]Deliveries, which are assumed to be equal to output.

Operations at the mine of Consolidated Churchill Copper Corporation Ltd. were terminated in March 1975.

Open-pit mining at Wesfrob Mines Limited is scheduled for completion in 1977. Development of the Dela-Blujay underground zone was started in 1975.

In 1975 Gibraltar Mines Ltd. continued to mine the Granite Lake open-pit mine. Production included 1.3 million tons of ore from claims held by Cuisson Lake Mines Ltd.

Granby Mining Corporation (Granby) commenced delivery of copper concentrates from the Phoenix mine to a smelter in the United States. It also became necessary to divert part of the copper concentrate produced at the Granisle mine to West Germany during the year. Both mines previously shipped to Japanese buyers.

At the Granduc mine of Granduc Operating Company (Granduc) operations were conducted on a reduced scale throughout 1975.

Lornex Mining Corporation Ltd. (Lornex) reduced ore production substantially in 1975. The Lornex copper concentrate sales contract with a consortium of Japanese companies was modified in October 1975 to provide for the delivery by Lornex of fixed amounts of copper concentrates in each of the years 1976 through 1979. Previously the Japanese buyers were the sole purchasers of the entire output of copper concentrates from Lornex, with no fixed quantity defined. The amending agreement permits Lornex to sell elsewhere, in each of these years, copper concentrates available from production in excess of the revised commitment to the Japanese consortium, and from accumulated inventories. Upward adjustments were also agreed upon in treatment charges of concentrates delivered to the Japanese consortium. Total capital expenditures at Lornex required in the five years 1975 through 1980 were estimated in 1975 to be $46 million. A major addition was made to ore reserves as a result of a re-evaluation program which was completed in 1974. Ore reserves, as of December 31, 1974, were increased from 257 million tons with an average grade of 0.425 per cent copper and 0.014 per cent molybdenum to 432 million tons with an average grade of 0.411 per cent copper and 0.014 per cent molybdenum. These reserves were reduced in 1975 by the amount of ore mined.

All copper concentrates produced at Noranda's Bell Copper Division were shipped to the Horne smelter at Noranda in 1975

At the Ingerbelle pit of Similkameen Mining Company Limited, production was affected by a nine-week strike at the mine which began on October 18, 1975. The capacity of the concentrator was increased to 22,000 tons a day in September, permitting the milling of lower-grade ore.

Extraction of known reserves at the Vanada operation of Texada Mines Ltd. is expected to be completed by the end of 1976 or early in 1977.

The copper concentrate sales agreement for production from the Island Copper mine of Utah International Inc. provides for sale of all production to Japanese buyers through 1976, and approximately 64 per cent of its production during the succeeding five years. Deliveries in 1975 surpassed the strike-affected 1974 deliveries, in spite of second-quarter-1975 shipping deferrals undertaken at the request of Japanese purchasers.

At the Buttle Lake operation of Western Mines Limited the amount of ore mined from underground increased from 73 per cent in 1974 to 82 per cent in 1975. Exploration and development expenditures were severely curtailed in 1975 to contain costs. In November, Brascan Resources Limited made arrangements to purchase effective control of Western Mines Limited. Outside exploration expenditures amounted to $1.5 million in 1975.

The Afton Copper Project. Teck Corporation Limited decided in October 1975 to develop a new copper mine and build a smelter at the Afton property, near Kamloops, British Columbia. This project is the most ambitious yet undertaken by this company and will have capital costs estimated at $80 million. The mine will be developed initially by open-pit methods. Ore reserves within the boundaries of the open pit are estimated to be 34 million tons with an average grade of 1.0 per cent copper. It is expected that the deposit will also be mined from underground to develop the deeper parts of the orebody. The concentrator will produce a highly metallic concentrate by gravity methods, in addition to a high grade flotation concentrate.

The Stikine Project. Hudson Bay Mining and Smelting Co., Limited has extended its agreement with Stikine Copper Limited, Kennco (Stikine) Mining Limited and Cominco Ltd. to permit additional exploration of the property. The extension will last until April 30, 1976.

Yukon Territory. Under an agreement with Hudson Bay and Anglo American Corporation of Canada Exploration Limited (AMEX), a joint venture operates the underground mining of the Little Chief and Middle Chief orebodies of Whitehorse Copper Mines Ltd. In 1975 ore production was increased by the installation and operation of an underground crusher.

Northwest Territories. At the mine of Echo Bay Mines Ltd., Port Radium, the old workings of the Eldorado Nuclear Limited mine were dewatered to the seventh level during 1975.

Smelters and refineries. Operations at the Murdochville smelter of Gaspé Copper Mines, Limited improved in 1975. The smelter treated 386,000 tons of concentrates in 1975 compared with 343,000 tons in 1974. Anode copper production in 1975 was 73,200 tons compared with 69,700 tons in 1974. The sulphuric acid plant, which has a rated capacity of 300,000 tons of acid a year, produced 175,000 tons in 1974. This compares with acid production of 155,000 tons in 1974. Construction of the vat leaching plant was completed during 1975, but the precipitation section, as designed, did not operate successfully. Plant modifications were planned following further testing.

At the Horne smelter of Noranda Mines Limited, a concentrate shortage was experienced in 1975. As a result, anode production fell to 231,000 tons compared with 269,000 tons in 1974. Two reverberatory furnaces were placed on standby for a total of 74 days, and a third underwent modifications. The Noranda continuous-smelting reactor was modified to produce high grade matte instead of metallic copper which resulted in improved refractory life and throughput. The matte produced was processed into metal in the converters in the conventional smelter. Oxygen-enriched air blast had the effect of increasing the capacity of the continuous reactor by 30 per cent. Fuel consumption was reduced by one third.

At the Falconbridge smelter in the Sudbury area, construction of the modernized facilities began in March 1975. Up to the time of the strike of Falconbridge employees which began in August, foundation work and 23 per cent of steel work had been completed. Following the strike, which ended in early November, the construction program was temporarily deferred in order to conserve cash during difficult business conditions.

In April 1975, Inco announced plans to build a metal-processing facility at Sudbury for the direct rolling of metal powders. Total investment at the project is estimated at $29 million. Further refinements to the dust recovery system at the Copper Cliff smelter resulted in a further decrease in dust emissions to 15 per cent of pre-1972 levels.

At the Flin Flon smelter of Hudson Bay Mining and Smelting Co., Limited the new flue system was completed and a service hoist was installed in the new 825-foot stack.

At the Montreal refinery of Canadian Copper Refiners Limited (CCR), the installation was begun in 1975 on the first of several filter units to collect emissions from the anode furnaces. Also, a new process to decopperize refinery electrolyte for control of impurities was put into operation.

Texasgulf Inc. completed site preparation in 1975 for a new copper smelter and refinery beside the Hoyle concentrator and zinc reduction plant near Timmins. The capacity of the complex is intended to be 130,000 tons of refined copper a year. Construction will take place in two phases. The first phase will involve construction of one unit of 65,000 tons a year capacity, to be completed in early 1979. The second unit is to be built at an unspecified later date. An agreement was signed in mid-1975 with Mitsubishi Metal Corporation of Japan for the process licence and basic design of the smelter and refinery.

Sherritt Gordon Mines Limited placed major emphasis in 1975 upon development of the S-C Copper Process, a hydrometallurgical process for the recovery of copper from copper concentrates. The S-C Copper Process is a joint development between Sherritt and Cominco, supported by a Federal Government program. Construction of the S-C copper pilot plant at Fort Saskatchewan was completed and full-scale testing was begun at the end of the year.

The Afton Copper Project will include construction of a smelter which will employ the top blown rotary converter process (TBRC) developed by Inco. The smelter is expected to produce 25,000 tons of blister copper annually, which will be exported in billet form. Due to the low sulphur content of the Afton concentrates, roasting and acid recovery facilities will not be built at the smelter. The Afton smelter will become the only operating copper smelter in British Columbia and is expected to begin production in 1977 or 1978.

Table 8. Canada, consumption of primary copper in manufacture of semifabricated products, 1974-75

	1974	1975p
	(short tons)	
Copper mills products — sheet, strip, bars, rolls, pipe, tubes, etc.	74,767	41,629
Brass mill products — plate, sheet, strip, rods, bars, rolls, pipe, tubes, etc.	19,860	8,153
Wire and rod mill products	54,205	140,484
Miscellaneous	1,516	1,585
Total	150,348	191,851

Source: Statistics Canada.
p Preliminary.

World supply and demand

Mines. World mine production of copper fell to 8,209,000 tons in 1975, a 5.2 per cent drop relative to 1974 production of 8,656,000 tons. The United States, the world's largest producer, recorded a decrease of 11.6 per cent. Mine production decreased by 8.1 per cent in Chile, by 11.8 per cent in Canada, by 3.0 per cent in Zambia, and by 7.1 per cent in Zaire. Poland alone recorded a substantial increase in 1975, 36.4 per cent of 1974 production.

Because of the economic recession experienced in Japan in 1975, Japanese smelters were forced to reduce production. As a result, suppliers of copper concentrates to Japan agreed to reduce shipments in 1975.

Fighting in the former Portugese territory of Angola interrupted rail traffic from Zambia to the coast during August, disrupting Zambian copper shipments.

Table 9. World mine production of copper, 1974-75

	1974	1975
	(000 short tons)	
United States	1,597.0	1,411.0
U.S.S.R.	1,322.8[e]	1,322.8[e]
Chile	994.4	913.0
Canada	905.4	798.1
Zambia	769.4	746.2
Zaire	546.7	507.1
Poland	218.3	297.6
Philippine Republic	248.6	249.9
Australia	277.0	243.6
Republic of South Africa	197.4	197.2
Peru	235.0	194.0
Papua New Guinea	202.9	190.1
Yugoslavia	171.1	167.1
Japan	90.5	93.3
Mexico	91.2	88.2
Indonesia	71.2	68.5
Other communist countries	298.4[e]	302.6[e]
Other noncommunist countries	418.2	418.8
Total	8,655.5	8,209.1

Sources: *World Metal Statistics,* June 1976, and Statistics Canada.
[e] Estimated.

Zambia's two large mining groups declared a 20 per cent *force majeure* on September copper shipments. This was increased to 30 per cent and 40 per cent for the two companies respectively in October as difficulties were experienced in diverting shipments through Dar Es Salaam and Beira. The *force majeure* was still in effect at year-end.

Members of the Intergovernmental Council of Copper Exporting Countries (CIPEC) organization continued their production cutbacks, begun late in 1974, throughout 1975. At the Eighth Conference of Ministers of CIPEC held in November, it was decided to further extend these cutbacks until mid-1976.

The Government of Panama and Texasgulf signed agreements on the participation of Texasgulf in the development of the Cerro Colorado copper deposit in western Panama. Texasgulf will conduct a feasibility study to determine the viability of the project. Texasgulf will manage the project and have a 20 per cent equity participation. The Panamanian government will retain 80 per cent ownership, with an option to buy the Texasgulf interest after 20 years. The deposit is estimated to contain over one billion tons of material with an average grade of 0.6 per cent copper. It is planned to develop an integrated operation with an initial capacity of 150,000 tons of refined copper a year.

Smelters and refineries. World production of refined copper in 1975 amounted to 9,047,200 tons, down from 9,770,300 tons in 1974; a decrease of 7.4 per cent. The United States and Japan bore the brunt of the decrease, with production cutbacks of 17.1 per cent and 17.8 per cent respectively. Most world producers of refined copper produced less in 1975 than in 1974 with the notable exception of Poland, which increased production in 1975 by 21.6 per cent to 273,400 tons.

The Japanese smelting industry was seriously affected by the fall in world demand for copper in 1975. Large inventories of refined copper accumulated and the flow of imported copper concentrates, purchased world-wide under long-term contracts, was well in excess of requirements. Strenuous efforts were made by the Japanese to choke the supply of concentrates and to dispose of, or finance, excessive inventories. Western Canadian copper producers were approached during January with requests to reduce 1975 shipments by 15 to 30 per cent relative to 1974 shipments, and with request for higher treatment charges. A special Mining Industry Council recommended early in 1975 that a metals' stockpile be created, financed by the

Table 10. World production of refined copper, 1974-75

	1974	1975
	(000 short tons)	
United States	2,138.6	1,773.9
U.S.S.R.	1,488.1[e]	1,488.1[e]
Japan	1,097.9	902.7
Zambia	746.0	693.5
Chile	593.2	590.0
Canada	616.3	583.3
West Germany	466.9	465.4
Belgium	417.4	381.8
Poland	214.4	273.4
Zaire	280.5	231.5
Australia	215.8	214.3
United Kingdom	176.5	167.0
Yugoslavia	165.3	152.0
Spain	136.1	132.3
Republic of South Africa	97.6	95.2
Mexico	81.9	77.4
Sweden	66.0	61.9
Peru	43.0	60.6
Other communist countries	407.9[e]	411.7[e]
Other noncommunist countries	320.9	291.2
Total	9,770.3	9,047.2

Sources: *World Metal Statistics,* June 1976, and Statistics Canada.
[e] Estimated.

Japanese government at a cost c: .$148 million. The stockpile would have included 50,000 metric tons of copper. This recommendation was not acted upon. In April the Rio Tinto Zinc Corporation Limited made an unsuccessful proposal for the financing of these copper inventory surpluses as a means to stabilize world copper prices. The Japanese Ministry of International Trade and Industry again presented a stockpile program in September for the fiscal year beginning April 1, 1976. It is expected that this plan will be accepted and may be financed commercially, not with government funds. The stockpile would include 90,000 metric tons of copper and substantial quantities of other nonferrous metals and would cost approximately $167 million. Japanese stocks of refined copper at the end of 1975 were in excess of 250,000 metric tons.

In spite of the depressed state of the world copper smelting and refining industry in 1975, a number of new plants were at the construction or planning stage during the year.

Start-up of the Lakeshore plant project in Arizona was beginning at year-end. The project will produce 30,000 tons of copper cathodes and 35,000 tons of copper in precipitate annually. The Lakeshore project is owned 50 per cent by Hecla Mining Company and 50 per cent by El Paso Natural Gas Company.

Table 11. World consumption of refined copper, 1974-75

	1974	1975
	(000 short tons)	
United States	2,199.0	1,539.2
U.S.S.R.	1,289.7[e]	1,322.8[e]
Japan	916.0	888.7
West Germany	806.0	699.7
United Kingdom	547.7	496.6
France	456.6	401.8
Italy	339.5	339.5
Canada	297.7	216.2
Belgium	196.4	192.0
Brazil	191.7	171.1
Poland	165.3[e]	165.3[e]
Yugoslavia	131.5	162.9
East Germany	115.7[e]	132.3
Spain	158.6	132.2
Australia	134.0	113.5
Sweden	119.3	104.1
Other communist countries	563.8[e]	567.1[e]
Other noncommunist countries	633.5	601.4
Total	9,262.0	8,246.4

Source: *World Metal Statistics*, June 1976.
[e] Estimated.

Centromin Peru, a Peruvian state agency, commissioned a study of the feasibility of expanding its copper smelting and refining facilities at La Oroya to a capacity of 73,000 metric tons a year from the present 57,000 metric tons a year.

Minero Peru began initial operations at its Ilo copper refinery in October. The capacity of the plant is 150,000 tons a year. Before construction was completed it was decided to double the size of the plant to 300,000 tons a year. Construction on the second phase of the refinery is expected to be completed by the end of 1977.

Boliden Aktiebolag will expand its copper-smelting capacity at Roennskaer in northern Sweden from 85,000 metric tons a year to 100,000 metric tons a year by 1978.

Lepanto Consolidated Mining Company and Marinduque Mining and Industrial Corporation will build a new copper smelter on the Philippine Island of Negros Occidental. The smelter is scheduled to begin operating in 1978.

Table 12. World copper production and consumption, 1975

	Mine Production	Refined Production	Refined Consumption
	(000 short tons)		
United States	1,411.0	1,773.9	1,539.2
U.S.S.R.	1,322.8[e]	1,488.1[e]	1,322.8[e]
Japan	93.3	902.7	888.7
CIPEC	2,428.8	1,575.6	48.1
Europe	359.0	1,513.3	2,707.9
Canada	798.1	583.3	216.2
Other communist countries	600.2[e]	685.1[e]	864.8[e]
Other noncommunist countries	1,195.9	525.2	658.7
Total	8,209.1	9,047.2	8,246.4

Sources: *World Metal Statistics*, June 1976, and Statistics Canada.
[e] Estimated.

Consumption. World consumption of refined copper in 1975 is estimated to have been 8,246,400 tons, compared with 9,262,000 tons in 1974; a decrease of 11.0 per cent. In the noncommunist countries the decrease was even greater; an estimated 15.2 per cent.

The drop in consumption was most pronounced in the United States, both in tonnage and in percentage terms. United States consumption of refined copper was 1,539,200 tons in 1975 compared with 2,199,000 tons in 1974; a drop of 30 per cent.

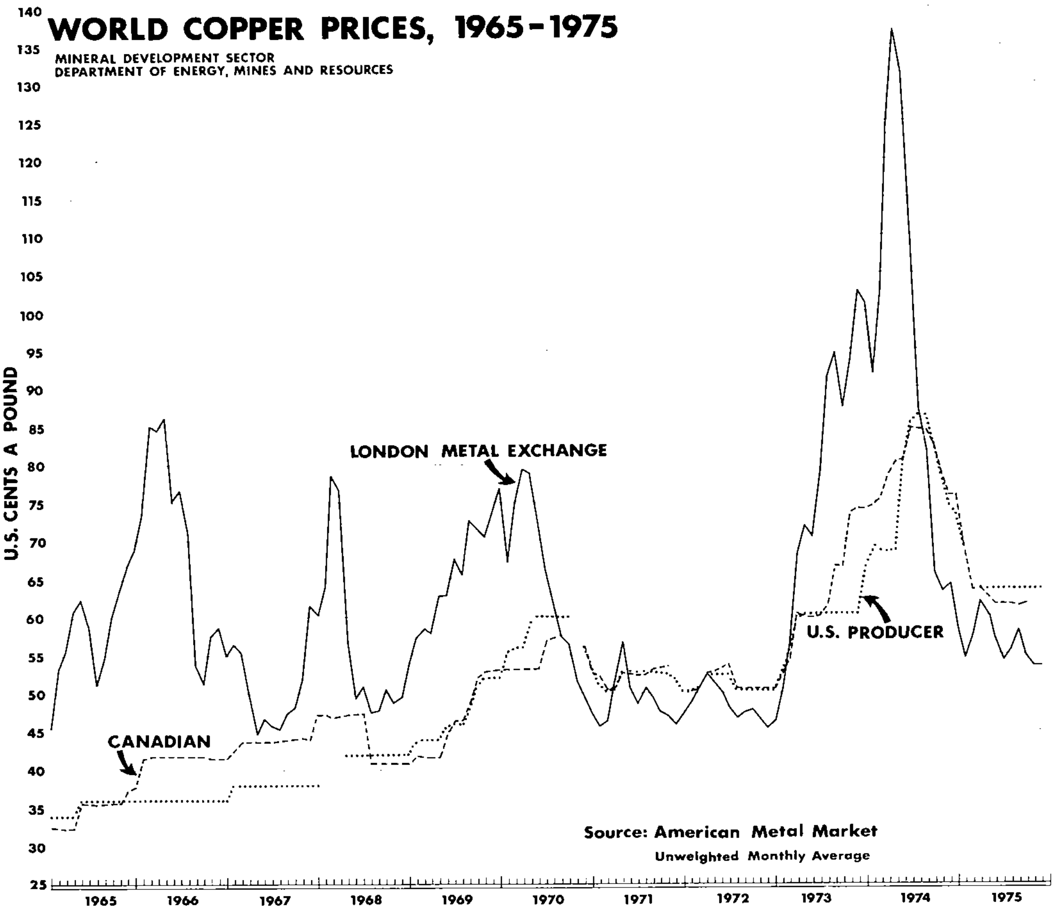
In Japan refined copper consumption dropped to 888,700 tons in 1975 from 916,000 tons in 1974 and 1,324,700 tons in 1973.

European consumption also declined substantially, but buyers tended to accept full deliveries of copper purchased under contract and to sell the amounts surplus to their requirements on the London Metal Exchange.

World copper stocks. World stocks of refined copper climbed to unprecedented levels in 1975. The American Bureau of Metal Statistics Inc. (ABMS), calculated world stocks for reporting countries to be 1,351,400 tons at the end of 1975. These statistics cover approximately 80 per cent of the noncommunist world producing countries. The ABMS world total was 729,000 tons for the end of 1974 and 336,300 tons for the end of 1973.

Japanese stocks at the end of 1975, according to the World Bureau of Metal Statistics, amounted to 329,000 tons. United States stocks according to the same authority were 510,800 tons.

The most visible stocks of refined copper were in the warehouses of the London Metal Exchange (LME) and the New York Commodity Exchange (Comex). At year-end these stocks were 550,000 tons at the LME and 100,000 tons at Comex. This compares with warehouse stocks at the end of 1974 of 139,000 tons at the LME and 43.000 tons at Comex.



Prices. The price of copper remained at depressed levels throughout 1975.

The LME cash price for copper wirebars opened the year at 55 U.S. cents a pound, and rose during February and March to a high for the year of 64.1 U.S. cents a pound on April 1. This was the anniversary date of the 1974 high of $1.49 U.S. a pound. For the balance of 1975 the LME cash wirebar price remained in the range of 53 to 60 U.S. cents a pound.

The United States producer price for copper was lowered on January 3 to 68.625 U.S. cents a pound for cathode and 70 U.S. cents a pound for wirebar. A further reduction occurred to 63.625 U.S. cents and 65 U.S. cents a pound, respectively, at the end of January, prices which held for the rest of the year.

The Canadian producer price for copper wirebars dropped from 75 cents a pound to 68.125 cents a pound on January 3, 1975, and again to 63.375 cents a pound on January 30. This price level was maintained for the balance of 1975.

International developments

CIPEC. Depressed prices arising from reduced demand, and high stocks of copper, were of great concern to CIPEC during 1975. At a meeting held by the organization in early April it was decided to implement the previously published plan to further reduce production and shipments of copper to a total of 85 per cent of earlier levels. In October, Australia announced that it would apply for associate membership in CIPEC as a result of its concern over the depressed state of the copper market and the serious problems faced by the developing nations resulting from it. Australia's application was accompanied by one from Papua New Guinea, also for associate membership, and one from Indonesia, for full membership. These applications were accepted at the Eighth Conference of Ministers of CIPEC. This was the first expansion of the organization since its establishment by Peru, Chile, Zaire and Zambia in 1967. Members of the expanded organization accounted for over 70 per cent of the copper exports of net copper-exporting countries in 1975.

CIPEC's Lima meeting decided to continue the restrictions on copper production, currently in force among member countries, until mid-1976. For the longer-term, the conference decided to initiate the opening of a dialogue with consumers to promote the negotiation of a stabilization agreement for copper prices. Member countries were also urged, subject to contractual obligations, to take measures to phase out their exports of concentrates and blister copper to those countries which process and re-export such material in the form of refined copper. The secretariat was instructed to prepare a study on how to finance and operate a buffer stock for copper.

United States policy on commodities

In a major policy speech at the United Nations on September 1, 1975, the United States proposed that the developing countries should be safe-guarded against cyclical declines in export earnings. It was recommended that a consumer-producer forum be held to discuss the efficiency, growth and stability of world copper markets. Price stabilization was not seen as a promising approach for many commodities, but the United States offered to join other countries in reducing the barriers to the importation of manufactured or processed forms of raw materials.

Meeting of copper consumers and producers

As a result of CIPEC intentions, proposals contained in the Kissinger speech to the United Nations General Assembly on September 1, 1975, and French diplomatic initiatives, it appeared likely at the end of 1975 that an international meeting would take place between consuming and producing countries.

Outlook. Copper continued to be in serious oversupply in 1975. Production cuts, although almost universal in the noncommunist countries, were not sufficient to fully offset the 15 per cent decline in world consumption. Total inventories rose throughout the year, and continued to rise in 1976. It is likely that a balance will be reached between total world supply and demand during the closing months of 1976. As the economic recovery progresses in late 1976 and 1977, copper consumption is expected to increase accordingly.

This increase in consumption will be supplied by the large world surplus of refined copper and concentrates, and by a gradual resumption of higher levels of production by the primary copper industry. After a decrease in world mine production of copper of five per cent in 1975, a small increase of less than five per cent seems likely in 1976. A larger increase is expected in 1977.

World mine, smelter and refinery capacity are expected to increase by approximately 30 per cent over the next five years. The demand side of the supply-demand equation, is as usual, much more difficult to foresee, but will correlate closely with the level of industrial output in North America, Japan and Europe. However, if the demand for newly mined copper continues to grow at the historic rate, this new capacity, together with the present surplus capacity and refined copper stocks on hand, should amply satisfy the growth in demand over the period.

In Canada, production of recoverable copper in 1975 was 11.8 per cent lower than in 1974 due primarily to cutbacks in mine production. Production of refined copper was also lower, by 5.4 per cent. In 1976 mine production is expected to increase by about five per cent to 825,000 tons. Refined production is expected to remain at about the same level as in 1975.

Table 13. Forecast of Canadian and world copper production and primary refined copper consumption

	1974	1975	1976	1977	1978	1979	1980	1981
	(000 short tons)							
Mine production								
Canada	905	798	825	870	880	900	960	990
World	8,573	8,209	8,300	8,700	9,300	9,900	10,300	10,700
Primary smelter production								
Canada	575	551	575	585	595	630	675	675
World	8,853	8,478	8,500	9,000	9,600	10,200	10,600	11,000
Primary refinery production								
Canada	616	583	610	610	640	660	685	685
World	9,560	9,047	9,100	9,600	10,200	10,800	11,200	11,600
World consumption of primary refined copper	8,956	8,246	9,000	10,000	10,600	10,900	11,200	11,600

Source: Mineral Development Sector, Department of Energy, Mines and Resources, Ottawa.

The increase in mine production is expected to continue in 1977, but not to reach the 1974 level until 1979.

Assuming that go-ahead production decisions are made on some of the known copper deposits in British Columbia during 1976 and 1977, a substantial net increase in Canadian mine capacity can be expected around 1980. If a favourable mining investment climate is fully restored in British Columbia, the province can be expected to achieve an even more dominant position relative to the other copper-producing provinces in Canada.

The trend towards further processing of copper ores and concentrates in Canada had achieved considerable momentum by the end of 1975. It is expected that by 1980, smelting capacity in British Columbia will have increased by at least 25,000 tons a year, and that smelting and refining capacity in Ontario will have increased by at least 65,000 tons a year. This may be augmented by further new capacity in British Columbia if the policies of the government of that province are successful. As a result, the amount of copper concentrates available for export will very probably begin to decrease after 1978.

Tariffs

Canada

Item No.		GSP[1]	British Preferential	GATT	General
32900-1	Copper in ores and concentrates	free	free	free	free
33503-1	Copper oxides	free	free	15%	25%
34800-1	Copper in pigs, blocks or ingots, cathodes plates, copper matte and blister and copper scrap, per lb.	free	free	free	1½¢
34820-1	Copper in bars or rods, for manufacture of trolley, telegraph, telephone wires, electric wires and cables	free	free	5%	10%
34835-1	Electrolytic copper powder (expires Feb. 28, 1978)	free	free	free	10%
34845-1	Electrolytic copper wire bars, per lb (expires Feb. 28, 1976)	free	free	free	1½¢
35800-1	Anodes of copper	free	free	free	10%

Tariffs (concl'd)

United States

USTS No.		GSP	GATT
602.30	Copper ores and concentrates, on Cu content	free	0.8¢ a pound
612.06	Unwrought copper, on Cu content	free	0.8¢ a pound
612.10	Copper waste and scrap, on 99.6% of Cu content	free	0.8¢ a pound

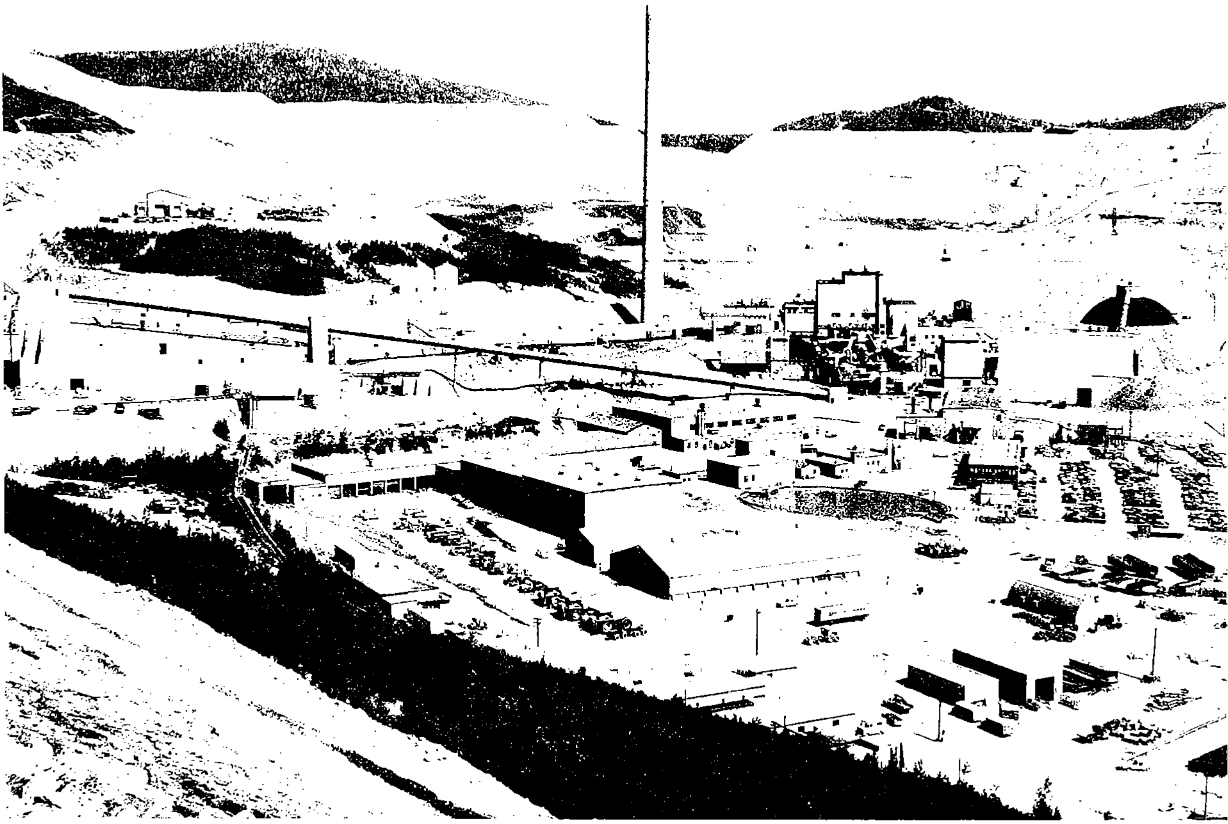
Japan

BTN No.		GSP	GATT
26.01	Copper ores and concentrates	free	free
74.01	(1) Matte, cement copper & native copper	free	free
	(2) Unwrought copper, other than matte, cement and native copper		
	(i) containing not more than 99.8% by weight of copper and used for smelting and refining	free	8.5%
	(ii) other — blister	free	8.5%
	other categories	free	24Y per Kg
	(3) Waste and scrap	free	2.5%

EEC

BTN No.		GSP	GATT
26.01	Copper ores and concentrates	free	free
74.01	Copper matte; unwrought copper; copper waste and scrap	free	free

1 GSP Generalized System of Preferences extended to all, or most, developing countries; some GSP rates are subject to quotas or withdrawal.



Overall view of the mill, smelter, offices services facilities, and open-pit mines of Gaspé Copper Mines, Limited Murdochville, P.Q.
(Photo by George Hunter)

Fluorspar

G.H.K. PEARSE

Fluorspar, or fluorite in mineralogical nomenclature, is calcium fluoride (CaF_2), an industrial mineral with a broad spectrum of uses. The most important uses are: for the manufacture of hydrofluoric acid and other fluorine chemicals; as a fluxing agent in various metallurgical processes, the most important being steel manufacture; for the manufacture of artificial cryolite, an essential cell ingredient in the electrolytic reduction of alumina to aluminum; in the refining of uranium ores and in the glass and ceramic industries.

In the past decade world fluorspar consumption grew rapidly because of increasing demands in the steel, aluminum and chemical industries. Due to a combination of technical, economic and environmental developments consumption has been stagnant during the first half of the present decade. In 1975, world consumption was an estimated 4.9 million tons.* Greater use of the basic oxygen process, in steelmaking, which requires about three times as much fluorspar as a slag thinner than the more traditional basic open-hearth process, will increase the demand for fluorspar in this sector in spite of the partial use of substitutes. Recent concern about concentrations of fluorocarbons in the upper atmosphere is expected to lead to restrictions on the use of aerosal spray products, a major end use in the fluorine chemical industry.

Production in Canada

Fluorspar is the principal source of the element fluorine. It occurs in many geological environments from low-temperature fracture fillings to high-temperature emplacements and, as a result, it is not restricted to any particular geological province in Canada. In fact, fluorspar is known to occur in all physiographic provinces with the exception of the interior plains. However, all fluorspar produced in Canada is currently mined from the Burin Peninsula in Newfoundland by one company.

Newfoundland Fluorspar Works of Aluminum Company of Canada, Limited (Alcan), produces fluorspar from three mines; Director, Tarefare, and Blue Beach. The three mines are located near the village of St. Lawrence in Newfoundland. The Director mine has been in operation for 33 years. In August 1968, the Tarefare mine commenced production at about 25,000 tons a year of fluorspar concentrate. Production from the Blue Beach mine began in 1972 and the mill capacity was increased to 1,200 tons of ore a day. Concentrates from these operations are shipped to Alcan's aluminum smelter at Arvida, Quebec, where they are upgraded by flotation and converted to aluminum fluoride for the reduction of alumina to aluminum. Small tonnages have been sold from time to time to Newfoundland Steel (1968) Company Limited for steel slagging. In 1975, shipments from Newfoundland totalled an estimated 80,000 tons, about half-normal output, as a result of a strike which began in June and was still in effect at year-end. Developments on extensive new reserves about a mile northwest of St. Lawrence were halted by the strike. The fluorspar veins on Burin Peninsula are genetically related to two large stocks of alaskite. Most of this favourable area is obscured by shallow overburden, but innumerable showings and float blocks containing fluorspar are known.

Allied Chemical Canada, Ltd. imports acid-grade fluorspar for the production of hydrofluoric acid at Valleyfield, Quebec and Amherstburg, Ontario. Some of the acid is utilized in the manufacture of various fluorine chemicals. Allied Chemical operates mines in Mexico and the United States to ensure an uninterrupted supply of fluorspar.

Huntingdon Fluorspar Mines Limited, with a plant near North Brook, Ontario, imports metallurgical-grade fluorspar to make five-pound briquettes for foundry use.

International Mogul Mines Limited has done considerable geological and mineralogical assessment work on its barite-fluorite deposits east of Lake Ainslie, Cape Breton Island, Nova Scotia. Indicated ore reserves are 2.97 million tons grading 28 per cent barite and 19 per cent fluorite. Pilot plant testing, with the objective of producing an acid-grade concentrate at an

*The short ton of 2,000 pounds is used throughout, unless otherwise stated.

Table 1. Canada, fluorspar production, trade and consumption

	1974		1975^p	
	(short tons)	($)	(short tons)	($)
Production (shipments)				
Newfoundland	. .	7,119,090	. .	7,000,000
Imports				
Mexico	117,877	6,856,000	94,034	6,813,000
Spain	4,044	217,000	46,581	3,649,000
United States	2,063	181,000	20,605	1,637,000
Italy	—	—	9,259	674,000
United Kingdom	25,526	1,101,000	2,829	259,000
France	7,289	432,000	—	—
Total	156,799	8,787,000	173,308	13,032,000
	1973		1974	
Consumption[1] (available data)				
Metallurgical flux[2]	35,452	. .	36,710	. .
Glass and glass wool	403	. .	484	. .
Enamels and frits	353	. .	295	. .
Other[3]	179,529	. .	74,023	. .
Total	215,737	. .	111,512	. .

Source: Statistics Canada.
[1]As reported by consumers; breakdown by Mineral Development Sector, Department of Energy, Mines and Resources, Ottawa. [2]Consumption as flux in the production of steel and magnesium, and use in foundries. [3] Includes consumption in the production of aluminum and chemicals and other miscellaneous uses.
^p Preliminary; . . Not available.

acceptable rate of recovery, has yet to prove successful. From 1940 to 1949, approximately 1,400 tons of fluorspar, along with some barite, were recovered from this deposit.

Prior to the First World War, small tonnages of fluorspar were mined from vein-type deposits in the Madoc district of Ontario. As a strategic material of great importance, it showed a marked increase in production during the war. After the war, production decreased substantially, but was stimulated once again during the Second World War by government assistance for exploratory drilling programs and by loans on capital equipment. From 1943 to 1947 some 25,000 tons were mined. Fluorspar was mined continuously in the Madoc area up to 1961 when severe underground flooding, lack of export markets, and increased mining costs made the operation uneconomic. Altogether, some 150,000 tons of fluorspar were mined in the Madoc area, production being derived from 24 separate properties. Most significant producing properties were along a prominent linear vein structure, the southern extension of which could still contain economically attractive reserves.

The Rock Candy mine, near Grand Forks, British Columbia, was mined intermittently from 1918 to 1942 and is controlled by Cominco Ltd. Substantial reserves probably remain.

Some fluorine is being recovered as fluosilicic acid from the processing of phosphate rock by Erco Industries Limited (formerly Electric Reduction Company of Canada, Ltd.), at Port Maitland, Ontario, and by Cominco Ltd., at Trail, British Columbia.

Other fluorspar occurrences of interest include the Liard River, British Columbia deposits explored a few years ago by Jorex Limited and Conwest Exploration Company Limited; Eaglet Mines Limited's widespread low-grade mineralization near Quesnel, British Columbia and Consolidated Rexspar Minerals & Chemicals Limited's large uranium-bearing, medium-grade fluorspar deposit adjacent to the Canadian National Railway line at Birch Island, about 60 miles north of Kamloops.

Uses, markets and trade

The major uses of fluorspar are: as a fluxing material in metallurgical and related industries; in the chemical industry for the manufacture of hydrofluoric acid and other fluorine compounds; in the glass and ceramic industries; in the refining of uranium ores and concentrates; and in the manufacture of artificial cryolite utilized in aluminum refining. Minor quantities of clear, transparent, colourless fluorite are used in optical equipment.

Fluorspar is marketed in three grades according to end-use, although, in times of shortage, high-grade material may be substituted in applications normally requiring lower-grade materials. These three grades are: acid grade, containing a minimum of 97 per cent CaF_2; metallurgical grade, containing 60-80 per cent CaF_2; and ceramic grade, containing 88-97 per cent CaF_2.

Acid grade. Over 50 per cent of the world's fluorspar requirement is for acid grade and is used in the manufacture of hydrofluoric acid. Most of this material is beneficiated by flotation to achieve the high CaF_2 content required. In general, two to three tons of ore must be mined to produce one ton of acid-grade fluorspar concentrate, and the production of one ton of hydrofluoric acid requires two tons of acid-grade concentrate and almost three tons of sulphuric acid. Hydrofluoric acid, produced according to the reaction $CaF_2 + H_2SO_4 \rightarrow CaSO_4 + 2\ Hf$, has a variety of uses, but by far the most important is in the aluminum and fluorocarbon industries which account for some 80 per cent.

About one-third of all hydrofluoric acid produced is used by the aluminum industry. Hydrofluoric acid is reacted with a sodium salt and aluminum fluoride to produce artificial cryolite, an essential cell ingredient for fluxing in the electrolytic reduction of alumina to aluminum. In general, about 45 pounds of cryolite and 40 pounds of aluminum fluoride are required for the production of one ton of primary aluminum. This is equivalent to 130 to 140 pounds of acid-grade fluorspar concentrate. Allowing for increased cell efficiencies and fluorite recoveries from potlines, the above figure should be reduced to 120 pounds a ton of primary aluminum. Because fluorite is an essential raw material, many primary aluminum producers operate or participate in the operation of fluorspar mines to ensure uninterrupted and adequate supplies.

Over 40 per cent of hydrofluoric acid is consumed in the manufacture of fluorocarbons. Fluorocarbons, which are used in the manufacture of solvents, resins, plastics, films, refrigerants and aerosol propellants, are produced by reacting hydrofluoric acid with carbon tetrachloride or with chloroform. Fluorocarbons are currently under study as potentially harmful atmospheric pollutants. It is believed that these substances react with and diminish ozone which occurs as a layer in the upper atmosphere and which serves to filter out much of the sun's ultraviolet energy.

Fluorspar is used in uranium refining. Uranium dioxide is reacted with anhydrous hydrofluoric acid to form a green salt (UF_4), which is then reacted with elemental fluorine in the form of fluorine gas to form UF_6. For each ton of uranium processed into uranium hexafluoride, one and two-third tons of fluorspar are required. This presently minor use is expected to develop rapidly as nuclear energy becomes increasingly more important.

Metallurgical grade. About half of the world's fluorspar output is consumed as a metallurgical fluxing agent, primarily in the manufacture of steel. Metallurgical-grade fluorspar is used in the steel industry to remove impurities during melting and also to improve separation of metal and slag in the furnace by increasing the fluidity of the slag. Consumption of fluorspar in the steel industry has, in recent years, increased substantially because of changing technology. Steelmakers have shifted increasingly from the basic open-hearth process to the basic oxygen process. The latter consumes from 10 to 15 pounds of metallurgical-grade fluorspar for each ton of steel produced, compared with three to five pounds in the open-hearth process. The electric furnace process consumes from eight to ten pounds of metallurgical-grade material for each ton of steel produced. The basic oxygen process substantially reduces production costs, doubles capacity per unit dollar of capital cost and reaches heat much faster than the open-hearth process. Within the next decade, older basic open-hearth furnaces should be replaced by more efficient, new basic-oxygen or electric furnaces. Faced with higher prices and uncertain supply conditions, the steel industry will attempt to find methods of reducing consumption of fluorspar. In addition, some major consumers have become involved in exploration for fluorspar reserves. No satisfactory total substitute for fluorspar as a fluxing agent in steelmaking has been found, although research in this area is considerable and indications are that the growth of metallurgical-grade reserves is not keeping pace with requirements. Consequently, steelmakers may have to switch to higher-grade, higher-cost material, produced as flotation concentrates and converted into pellet or briquette form. World consumption in the steel industry is

Table 2. Canada, fluorspar production, trade and consumption, 1966-1975

	Production[1]	Exports	Imports	Consumption
	(short tons)			
1966	79,000	12	75,324	166,275
1967	72,762	. .	94,244	155,349
1968	105,000	. .	115,465	178,901
1969	131,600	. .	104,382	200,827
1970	136,800	. .	94,682	212,949
1971	90,000[e]	. .	225,093	197,449
1972	160,700[e]	. .	71,910	232,128
1973	151,000[e]	. .	169,553	215,737
1974	150,000[er]	. .	156,799	111,512
1975[p]	100,000[e]	. .	173,308	. .

Source: Statistics Canada.
[1]Shipments reported in annual reports of Alcan Aluminum Ltd. for 1964-1970. Shipments 1971-75 are estimates based on the U.S. Bureau of Mines, *Minerals Yearbook*.
[p] Preliminary; . . Not available [e] Estimated; [r] Revised.

currently about 3.9 million tons a year. Metallurgical-grade fluorspar is also used as a flux in foundries and in the reduction of dolomite to magnesium.

Ceramic grade. Ceramic-grade fluorspar is used as an opacifier in enamels and opal glass. It is also used to a limited extent in the manufacture of clear glass as an active flux, as a contributor to the gloss and as a decolourizer. Much of this grade of fluorspar concentrates can be used for the manufacture of hydrofluoric acid or as pellets and briquettes for steelmaking. This latter use has been provided for in this way during shortages of metallurgical-grade fluorspar.

Canadian consumption and trade

Most fluorspar consumed in Canada, and virtually all domestic production, is used in the manufacture of aluminum fluoride for the electrolytic reduction of alumina to aluminum.

In 1975 fluorspar imports were 173,308 tons, an increase of 10.5 per cent from the previous year. Imports tend to vary widely from year to year in an inverse relationship to swings in production, caused primarily by strikes. Mexico provided 54 per cent of total imports, with the remainder coming from Spain, the United States, Italy and the United Kingdom.

Prior to 1957, much of Canadian production was exported to the United States and Europe. In 1958, exports declined abruptly because of the development of alternative low-cost deposits in Mexico by large consumers in the United States.

World review

Rapid growth in fluorspar consumption by the steel, chemical and aluminum industries; coupled with a stagnant ore-reserve situation during the 1960s, raised fears of a shortage towards the end of the decade. Under the impetus of tightening supply and rising prices, intensive exploration efforts in various parts of the world were successful in substantially augmenting reserves. Expanded and new facilities were brought on stream to meet the expected strong demand. However, coincident with the surge in production came a slackening in demand due to an economic slowdown in the major consuming nations, notably the United States and Japan. During the latter part of 1971 and the first half of 1972 an over-supply situation, especially of acid-grade material, developed in many areas. World production at 4.9 million tons in 1975 is little changed from that of the previous five years. Strong growth in consuming sectors in 1974 was met by withdrawals from large inventories, notably in Europe where output was deliberately cut back. Entry into recession precluded stimulation of production during 1975.

Mexico continued to rank as the world's largest supplier, producing 1.2 million short tons, or 25 per cent of total output, in 1975. Fluorspar mining began in Mexico prior to The First World War. However, the industry received its greatest stimulus during The Second World War when the United States government, cut off from European sources, encouraged exploration and development in Mexico. Most production is mined in the State of San Luis Potosi in the Zaragoza area where two major producing mines are located within a mile of each other. The Las Cuevas mine, which is the largest, accounts for some 40 per cent of total Mexican metallurgical-grade output. This underground operation is an affiliate of Noranda Mines Limited. The rapid growth of fluorspar production in Mexico from 474,000 tons in 1963 has paralleled consumption increases in the United States, which relies upon Mexico for most of its import requirements. Similarly, stagnation of production over the last few years reflects the United States' demand.

Quimica Fluor S.A.'s hydrofluoric acid plant at Matamoros started up in 1975. It is one of four originally proposed in 1971.

The Mexican Fluorspar Institute, a producer organization, was formed in 1974. This body, backed by the government, formulates policy on sales and prices.

The United States is the world's largest consumer and is heavily reliant on imports to meet demand. In 1975 United States production fell 30 per cent to 122,353 tons, largely as a result of strikes during the year. Imports from Mexico were 1,050,445 tons, 50 per cent of which was acid spar. Most output in the United States comes from the Illinois-Kentucky district and is produced by two companies, Ozark-Mahoning Company (majority interest purchased by Pennwalt Corporation during 1975) and Allied Chemical Corporation which, through acquisition, took over the former Minerva Oil Company holdings. The new mine and mill of Cerro Corporation near Salem, Kentucky, started up in 1974, but mining problems prevented achievement of capacity output during 1975. Other states producing fluorspar intermittently are: Montana, Colorado, Idaho, Arizona, New Mexico and Utah. Little news of developments at Lost River Mining Corporation Limited's reportedly extensive deposits near Teller, Alaska was forthcoming during the year. Drilling by United States Borax & Chemical Corporation on its new fluorspar-barite deposit in the Sweetwater district 40 miles southwest of Knoxville, Tennessee has thus far delineated over 50 million tons of 15-35 per cent CaF_2 amenable to open-pit mining.

In 1975 Spain produced an estimated 400,000 short tons. Significant new reserves have been found in the Caravia district in Oviedo Province. Much of Spanish production is exported, mostly to the United States and West Germany. Estimated French production was 270,000 short tons.

Italy, also a major producer, shipped an estimated 260,000 tons in 1975. Production in Britain was an estimated 190,000 tons in 1975, considerably down from 1973.

The U.S.S.R. is the world's second-largest producer of fluorspar, with an output of about 500,000 tons in

1975. Domestic supply has fallen short of requirements for some years, and imports in 1975 exceeded 400,000 tons. The People's Republic of China, North Korea and Mongolia, a rapidly growing producer, together produce approximately 500,000 tons a year.

Thailand's output remained substantially below the 1971 output of 47,015 tons. As a result of cutbacks in orders, principally from Japan, production in 1975 was below 400,000 tons. Reserves are reportedly 12 million tons of 60 per cent CaF_2 and large deposits indicated in the upper reaches of the River Kwai have received attention. Limiting factors on production and market development include primitive mining and beneficiating techniques, and costly and difficult transportation from producing areas to points of export. Loading facilities at Bangkok also present a bottleneck to efficient ocean transport. The Thai government has taken an active interest in the industry and is moving to eliminate these drawbacks. A United Nations study and report on these problems was completed during the year.

The Republic of South Africa's output more than doubled between 1968 and 1971 to 263,000 tons. Production in 1975 was an estimated 227,000 tons, down marginally from that of 1974. Exports increased 13 per cent to 155,000 tons, a performance contrasting with that of other producing countries. This country has about 25 per cent of the world's measured CaF_2 reserves and its production will likely make up an increasing proportion of world output over the long term.

Namibia (formerly South-West Africa), Kenya, Tunisia and Morocco are all significant producers.

Until recently, South America produced limited quantities of hand-sorted metallurgical grade fluorspar. Exploration and development is moving along rapidly in both Brazil and Argentina and output from this continent has risen to about 150,000 tons.

Table 3. World fluorspar production, 1973-75

	1973	1974	1975[e]
	(short tons)		
Mexico	1,196,992	1,226,000	1,200,000
U.S.S.R.	490,000	500,000	500,000
Spain	430,000	415,000	400,000
Thailand	377,079	430,000	390,000
Republic of South Africa	231,842	229,000	227,000
People's Republic of China	280,000	300,000	300,000
France	330,000	300,000	270,000
Italy	259,630	270,000	260,000
Mongolia	110,000	265,000	260,000
United Kingdom	220,000	259,000	190,000
United States	248,601	201,000	130,000
Canada	151,000	150,000	100,000
Other countries	602,705	604,000	600,000
Total	4,927,849	5,149,000	4,900,000

Source: U.S. Bureau of Mines, National Institute for Metallurgy (South Africa).
[e]Estimated.

Outlook

The performance of the fluorspar industry necessarily parallels development in the steel, chemical and aluminum industries, which together account for 95 per cent of fluorspar consumption.

Conversion from the open-hearth process to the basic-oxygen process for steelmaking, and vigorous growth in the chemical and aluminum industries during the 1960s accelerated fluorspar consumption. A hiatus in this growth during 1971 and much of 1972 obviated a tight-supply situation, and both consumer and producer stocks, particularly of acid grade, grew

Prices

United States fluorspar prices, quoted in Engineering and Mining Journal of December 1975.

(net ton fob Illinois and Kentucky, CaF_2 content, bulk)

	($)
Ceramic, calcite and silica variable, CaF_2	
88-90%	90-100
95-96%	95-106
97%	100-115
In 100-lb paper bags, extra	9
Metallurgical pellets, 70% effective CaF_2	83-88
Acid, dry basis, 97% CaF_2	
Carloads	95-115
Less than carload	not reported
Bags, extra	9
Pellets, 88% effective	105
Wet filter cake, 8-10% moisture, sold dry content — subtract approx.	3.00
Dry acid concentrates fob Wilmington, 97% CaF_2 st	102.50-125
European wet filter cake, 8-10% moisture, sold dry content, duty pd. st cif Wilmington/Philadelphia term contracts (spot material $5-10 higher)	105-117
Mexican	
Metallurgical 70% fob cars	
Mexican border	60.50-61.00
Tampico, fob vessel	63.00-63.50
Acid, 97% + Eagle Pass, bulk	73.50-76.50

substantially. The boom in 1974 was arrested by year-end as the world economic climate deteriorated and output remained static during 1975.

World steel demand by the early 1980s is expected to exceed one billion metric tons, and continued growth in the BOF process for steelmaking will be the mainstay of growth in the fluorspar industry.

Consumption of fluorspar in the aluminum industry is expected to level off over the medium term as fluorine emissions from potlines are reduced and greater efficiency in recycling is achieved. Also, recovery of fluorine from phosphate rock processing has begun and is currently substituting for fluorspar in the aluminum industry. This source of fluorine will grow in importance. The outcome of the controversy over the environmental effects of fluorocarbons is likely to weigh in favour of caution, and decline in this sector could result. These negative effects on the demand for fluorspar will undoubtedly be compensated for in the long-term by accelerated use in uranium refining and developments in the chemical industry.

Fluorine, the most electronegative of all elements reacts with almost all organic and inorganic substances and in view of this property, only the surface of its potential as a chemical has been scratched.

Tariffs

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
Canada					
29600-1	Fluorspar	free	free	free	free
United States					
			($/lt)		
522.21	Fluorspar, containing over 97% calcium fluoride		2.10		
522.24	Fluorspar, containing not over 97% calcium fluoride		8.40		

Sources: For Canada, The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division. For United States, Tariff Schedules of the United States, Annotated (1976) T.C. Publication 749.

Gold

J.J. HOGAN

Gold production in Canada in 1975 was estimated at 1,674,000 ounces* valued at $276,125,000 compared with 1,698,392 ounces in 1974 valued at $263,794,245, a decline in volume of 1.4 per cent. The average yearly afternoon fixing prices of gold on the London Gold Market converted to equivalent Canadian dollars for the years 1975 and 1974 were $165.03 and $155.32 respectively. As a result of the higher average gold price on the free market, the dollar value of gold production in 1975 reached an all time high, the previous high being in 1974. Volume of gold production in Canada has declined continuously since 1960 when 4,628,911 ounces were produced. The largest gold production in Canada for any year was 1941 when 5,345,179 ounces were produced.

Canada has been one of the world's leading producers of gold and, since production was first officially recorded in 1858, has produced 201.1 million ounces to the end of 1975 valued at $7,166 million. Although most of the provinces and territories have contributed to the total output, the largest producers in decreasing order of output, were Ontario, Quebec, British Columbia, Yukon Territory and the Northwest Territories.

In 1975, the 21 operating lode or auriferous quartz gold mines in Canada produced 1,240,000 ounces of gold compared with 1,212,911 ounces in 1974, the first increase in lode gold production since 1960. The reason for the rise in production of gold from lode mines was that a mine in Quebec recorded its first full year of production and added significantly to the gold output. In Quebec, a lode mine that came into production in 1974 closed in 1975. Gold derived from base metal mining amounted to 430,000 ounces in 1975 compared with 475,678 ounces in 1974. A reduction in the output of copper was the main reason for the decline in byproduct gold production. A small amount of gold was recovered from placer deposits of the Yukon Territory and British Columbia. In 1975, Ontario accounted for 46.3 per cent of the national total, followed by Quebec with 27.8 per cent. Northwest Territories 11.1 per cent and British Columbia 8.6 per cent.

The substantial increase in the gold price which began in 1972 has enabled most of the Canadian gold mines to continue to operate at a profit, and thereby play an important role in the economy of those communities dependent on gold mining, and whose economy over the years was helped through the assistance extended to such mines under the provisions of the Emergency Gold Mining Assistance Act. The expiry date of the Act is June 30, 1976 but no gold mines have received assistance since 1971 because it was more profitable for them to sell their gold on the open market.

On July 30, 1975, Parliament gave Royal Assent to an Act to amend the existing Olympic (1976) Act, passed in 1973, which amendment authorizes the issue for circulation in Canada of gold coins of the denominations of $100 commemorating the Olympic Games to be held in 1976. Such coins shall bear the date 1976. This new legislation also provides that each of the new gold Olympic coins will be legal tender for payment of an amount not exceeding $100.

The coins to be minted are a 14 carat gold coin and a 22 carat proof gold coin. The specifications for the 14 carat gold coin are; gold 58.3 per cent, copper 31.3 per cent, silver 4.0 per cent, zinc 6.4 per cent, weight 13.34 grams (gms), weight of contained gold 7.7759 gms (¼ ounce), diameter 26.53 millimeters (mm) and gauge 1.82 mm. Specifications for the 22 carat gold coin are; gold 91.66 per cent, copper 7.34 per cent, silver 1.00 per cent, weight 16.96 gms, weight of contained gold 15.5517 gms (½ ounce) diameter 24.49 mm and gauge 1.96 mm. These will be the first $100 official gold coins minted by the Canadian government. At the end of 1975 no decision had been reached on the price at which the coins would be sold or the number of coins that would be minted.

In 1975, the Republic of South Africa was, by far, the leading world gold-producing country, followed by the U.S.S.R., Canada and the United States. Other significant gold producing countries were Ghana, Rhodesia, Papua-New Guinea, the Philippines and Australia. Smaller producers were Brazil, Colombia, Japan, Mexico, Peru, Zaire and the Dominican Republic.

* The term "ounce" refers to the troy ounce throughout unless otherwise stated.

In its 46th annual report for the fiscal year ending March 31, 1976 the Bank for International Settlements (BIS) reported gold production in the noncommunist world for the year 1975 at 927.8 metric tons (mt), equivalent to 29.83 million ounces, compared with 993.4 mt (31.94 million ounces) in 1974, a decline of 6.6 per cent. In 1975, the Republic of South Africa produced 708.1 mt (22.76 million ounces) of gold compared with 758.5 mt (24.39 million ounces) in 1974. In both 1975 and 1974 South African gold production represented 76.3 per cent of the noncommunist world total. Canada accounted for 5.4 per cent of the noncommunist world production. Table 2 shows the U.S. Bureau of Mines world gold production estimates for the years 1973 and 1974 at 43,007,573 and 39,760,673 ounces, respectively. For these years the U.S.S.R. gold production was estimated at 7,100,000 and 7,300,000 ounces, respectively. Consolidated Gold Fields Limited, a company that holds a large interest in South African gold mining, in its report "Gold 1976" estimated gold production in the U.S.S.R. for the years

Table 1. Canada, production of gold, 1974-75.

	1974	1975[p]
	(ounces)	
Newfoundland		
Base-metal mines	11,605	13,000
New Brunswick		
Base-metal mines	4,296	5,000
Quebec		
Auriferous quarts mines		
Bourlamaque-Louvicourt	128,144	134,000
Malartic and Matagami	176,295	209,000
Total	304,439	343,000
Base-metal mines	136,120	122,000
Total Quebec	440,559	465,000
Ontario		
Auriferous quartz mines		
Larder Lake	173,882	170,000
Porcupine	253,966	256,000
Red Lake & Patricia	296,157	285,000
Total	724,005	711,000
Base-metal mine	77,100	64,000
Total Ontario	801,105	775,000
Manitoba-Saskatchewan		
Base-metal mines	67,710	60,000
Placer operations	—	—
Total Manitoba-Saskatchewan	67,710	60,000
Alberta		
Placer operations	97	—
British Columbia		
Auriferous quartz mines	—	—
Base-metal mines	160,791	143,000[1]
Placer operations	1,290	1,000
Total British Columbia	162,081	144,000
Yukon Territory		
Base-metal mines	18,056	23,000
Placer operations	8,416	3,000
Total Yukon	26,472	26,000
Northwest Territories		
Auriferous quartz mines	184,467	186,000
Base-metal mines	—	—
Total Northwest Territories	184,467	186,000
Canada		
Auriferous quartz mines	1,212,911	1,240,000
Base-metal mines	475,678	430,000
Placer operations	9,803	4,000
Total	1,698,392	1,674,000
Total Value	$263,794,245	$276,125,000[2]
Average value per oz.[3]	$155.32	$165.03

Source: 1974 Statistics Canada; 1975, Statistics Canada and company reports. Breakdown by type of operation by the Statistics Section, Mineral Development Sector, Department of Energy, Mines and Resources, Ottawa.
[1]Production from Dusty Mac Mines Limited included in base-metal mines. [2]Value not necessarily based on average gold price for 1975. [3]Average of London Gold Market afternoon fixings in Canadian funds.
[p]Preliminary; — Nil.

1974 and 1975 at 13.53 million ounces and 13.09 million ounces, respectively. There is a wide discrepancy between the two estimates on gold production in the U.S.S.R. The general consensus is that the U.S.S.R. gold production will continue to increase over the next few years.

In 1975, the Republic of South Africa sold its gold production on the world market to meet balance-of-payment obligations. According to the BIS report the market supplies of new gold were about the same as in 1974. Production in the noncommunist world in 1975 was down, but an estimated sale of 150 mt (4.82 million ounces) by communist countries, a decline in the western world's official gold reserves of 50 mt (1.61 million ounces), which includes the market sales of 39 mt (1.25 million ounces) by the United States Treasury and 16 mt (0.51 million ounces) out of South Africa's official reserve, brought the gold available for non-monetary demand up to 1,130 mt (36.33 million ounces), about 4 per cent less than in 1974. The BIS estimated that gold sales by the communist countries were 150 mt in each of the years 1974 and 1975. The report "Gold 1976" showed demand and supply of gold to be in balance in 1975 and placed private purchases at 178 mt (5.72 million ounces) in 1975 a substantial decline from the 519 mt (16.69 million ounces) purchased in 1974.

Trading in gold futures was established on five commodity exchanges in the United States on December 31, 1974. The gold futures contract specification set by the Commodity Exchange Inc. (Comex) of New York and the International Monetary Market (IMM) of Chicago call for trading in contracts of 100 ounces each. The contract size established by the Chicago Board of Trade (CBT) was three bars, each weighing one kilogram (32.15 ounces) for a total weight of 96.45 ounces, and by the New York Mercantile Exchange (NYME) of New York, and MidAmerican Commodity Exchange of Chicago, was one kilogram bar. Comex and IMM accounted for the largest number of transactions on the futures exchange. With the introduction of the futures market in the United States the speculators can do their trading on this market rather than go into the open market for gold purchases. The gold futures contract specifications on the Winnipeg Commodity Exchange calls for trading in either 400-ounce contracts or 100-ounce contracts.

The gold mining industry received a series of setbacks in 1975. The anticipated strong demand for gold by United States citizens in 1975 following the legalization of gold ownership in that country, on and after December 31, 1974 did not develop. The announcement by the Secretary of the Treasury in December 1974 that the United States government would offer gold from its official reserves for sale by auction, and two subsequent sales in 1975 were largely responsible for stopping the gold price rise and eventually leading to a price decline. The announcement on August 31, 1975 by the International Monetary Fund (IMF) that the Interim Committee had agreed to sell by auction one-sixth of the approximate 150 million ounces of gold in its official reserves to obtain funds to assist developing countries resulted in a sharp fall in the gold price.

Canadian developments

Atlantic provinces. All gold produced in the Atlantic provinces in 1975 was derived as a byproduct of base metal ores. Exploratory programs were carried out on some of the gold prospects in the former gold-producing areas in Nova Scotia.

Quebec. Changes to the mill circuit at Agnico-Eagle Mines Limited resulted in a significant improvement in the recovery of gold and in an increase in the milling rate in the latter half of 1975 to near the rated capacity of 1,000 tons* of ore a day. Underground diamond drilling to test the area below the 1,800 foot level has confirmed the existence of the ore zone to the 2,250 foot level. The shaft will be deepened 1,100 feet to the 2,965 foot horizon and seven new levels established. Camflo Mines Limited completed the deepening of its shaft by 600 feet to the 3,365 foot horizon and established four new levels. Waste and ore passes were being driven from these lower levels to prepare this section of the mine for exploration and development. The capacity of the mill was increased from 1,000 tons to 1,250 tons a day. The mine of Chibex Limited, under management control of Valley Mining Corp., closed in mid-1975 because of poor operating results. The mine, the former producing mine of Key Anacon Mines Limited, came into production in November 1974. East Malartic Mines, Limited completed sinking the Barnat shaft 600 feet to a depth of 3,000 feet and began developing two low-grade porphyry zones for production. The ore from this operation will be trucked to the East Malartic mill for treatment. A plant modernization program was completed and this should improve the efficiency and profitability of the operation. Lamaque Mining Company Limited is using load-haul-dump equipment to drive an incline above the 1,500 foot level in the north end of the property and to mine flat orebodies as they are encountered. Ore passes are being driven on the lower levels of Sigma Mines (Quebec) Limited to prepare this section of the mine for exploration and development. Campbell Chibougamau Mines Ltd., a substantial producer of byproduct gold, closed in May 1975 as a result of the depressed copper price and labour problems.

Considerable exploration work was done on gold prospects in northwestern Quebec. Belmoral Mines

* The short ton of 2,000 pounds is used throughout unless otherwise stated.

Table 2. World gold production, 1973-1974

	1973	1974[p]
	(ounces)	
North America		
Canada	1,954,340	1,698,392
United States	1,175,750	1,126,886
Other countries	239,136	243,239
Total	3,369,226	3,068,517
South America		
Colombia	215,876	265,195
Brazil	203,096	210,000
Chile	97,995	118,829
Peru	104,490	110,000
Bolivia	35,964	41,600
Other countries	48,522	34,275
Total	705,943	779,899
Europe		
U.S.S.R.[e]	7,100,000	7,300,000
Yugoslavia	176,347	177,000
Sweden	80,923	85,000
Romania[e]	60,000	60,000
Other countries	91,740	77,889
Total	7,509,010	7,699,889
Asia		
Philippines	572,319	536,399
North Korea[e]	160,000	160,000
Japan	187,631	139,727
India	105,390	101,114
Other countries	138,919	169,429
Total	1,164,259	1,106,669
Africa		
Republic of South Africa	27,494,603	24,362,868
Ghana	722,531	760,000
Southern Rhodesia[e]	500,000	500,000
Zaire	133,650	126,449
Other countries	40,185	36,633
Total	28,890,969	25,785,950
Oceania		
Papua — New Guinea	722,341	726,047
Australia	554,278	520,102
Fiji	79,983	68,890
Other countries	11,564	4,710
Total	1,368,166	1,319,749
World Total	43,007,573	39,760,673

Sources: U.S. Bureau of Mines, Mineral Trade Notes, November 1975, and Statistics Canada.
[p]Preliminary; [e]Estimated.

Ltd. carried out an extensive surface diamond drill program on its large holdings to the north-east of Sigma. Bras d'Or Mines Ltd. began sinking a shaft at its property west of Belmoral. Campbell Chibougamau sunk a decline and carried out an underground exploration program at its optioned Gwillim Lake gold prospect near Chibougamau. A bulk sample of 16,588 tons processed through the company's mill graded 0.193 ounce of gold a ton. A private company, Darius Gold Mines Inc., carried out an extensive underground exploration program on the former O'Brien mine in the Cadillac district. Dumagami Mines Limited stripped and prepared a large area for open-pit mining. Work on this property was deferred until some semblance of stability develops in the gold price. A bulk sample shipment from the property of Goldex Mines Limited, in the Val d'Or district, to the custom mill of Malartic Gold Fields (Quebec) Limited, yielded only 526 ounces of gold averaging 0.067 ounce of gold a ton, much below the estimated grade. Quebec Sturgeon River Mines Limited did some underground exploratory work at its Bachelor Lake property, but deferred further work in the latter part of the year because of the decrease in the gold price and increased operating costs. A 1,200-foot decline was driven on the large, low-grade property of Thompson Bousquet Gold Mines Ltd., in Bousquet township. A 15,000-ton bulk sample was shipped to Malartic Gold Fields custom mill, but grade and haulage costs made the treatment of this ore at the Malartic mill impractical.

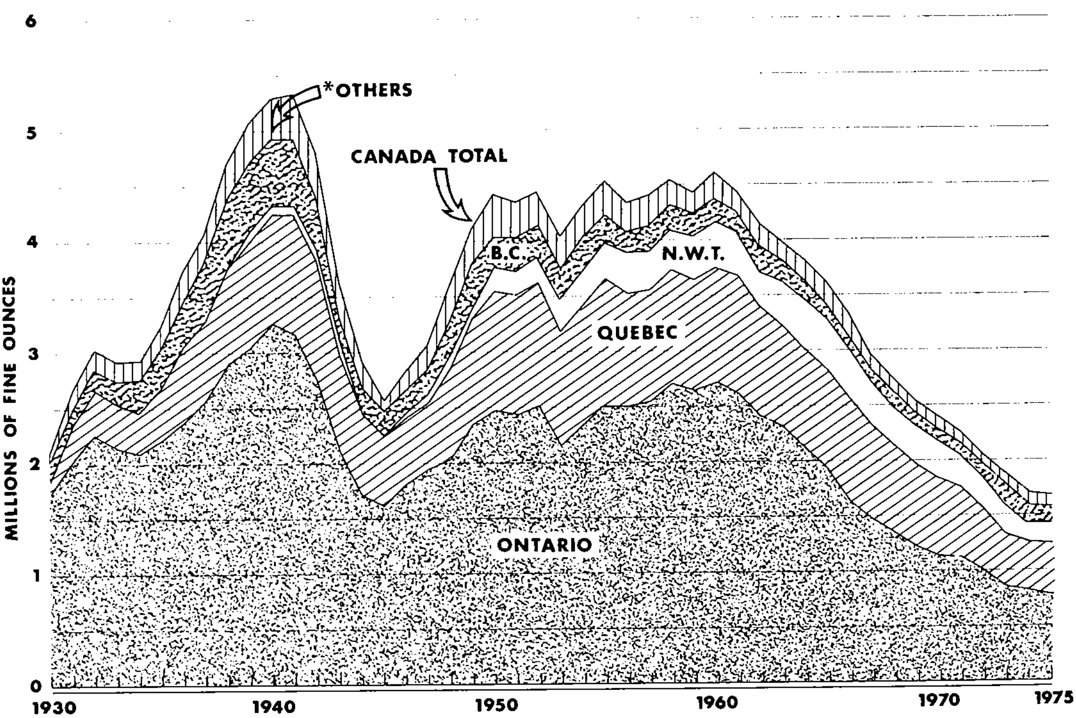
Considerable exploration work consisting mainly of geological surveys and surface diamond drilling was carried out on gold prospects in the gold mining districts of Quebec.

Ontario. Total gold production in Ontario in 1975 was 775,000 ounces, a decline of 3.3 per cent from 1974. The 12 gold mines that operated in the province in 1975 accounted for 91.7 per cent of the provincial total.

Campbell Red Lake Mines Limited in the Red Lake district, maintained its position as the leading gold producer in Canada. Dickenson Mines Limited began construction of a dust-collection system for the recovery of calcine and arsenic trioxide from the roasting of its ore. A mill test by Cochenour Willans Gold Mines, Limited was run on 20,000 tons of ore from the granodiorite zone on the adjoining property of Wilmar Mines Limited. The test results indicated that the grade of the ore was not sufficient to warrant mining. Tests were also performed on ore from

GOLD PRODUCTION by PROVINCES

MINERAL DEVELOPMENT SECTOR
DEPARTMENT OF ENERGY, MINES AND RESOURCES



* OTHERS = NFLD., N.S., N.B., MAN., SASK., ALTA., Y.T.
DATA SOURCE: STATISTICS CANADA

Wilmar's breccia zone, which was last mined in 1971 and results were unsatisfactory, forcing a closure of all operations on the Wilmar property.

The capacity of the Pamour Porcupine Mines, Limited mill in the Timmins area was increased from 2,500 tons to 3,000 tons a day. Pamour ran a mill test on 6,200 tons of ore from the property of Canadian Arrow Mines Limited and results indicated that further custom milling was not warranted under prevailing economic conditions. The drop in the price of gold in September 1975 and increased transportation costs forced The Mining Corporation of Canada, Limited to suspend mining operations at its New Joburke mine near Timmins.

In December, Rengold Mines Ltd. began tune-up operations at its leased property near Misanabi, the former Renabie mine. The initial milling rate is 300 tons a day and an increase to 500 tons is anticipated. Hollinger Mines Limited continued its underground exploration program on the optioned property of New Kelore Mines Limited that adjoins that of the Hollinger Ross mine on the north. Quebec Sturgeon River Mines Limited erected a headframe and ancillary facilities at its Stock township property as a further step in an exploration and development program. Work was deferred until there is an improvement in the price of gold.

Amoco Canada Petroleum Company Ltd., a wholly-owned subsidiary of Standard Oil Company (Indiana) reported a gold discovery near Sundy Lake in the Burnbush river area of northeastern Ontario about 125 miles northeast of Timmins. The company carried out a diamond drill program. Exploratory work consisting of geological mapping, and surface and underground drilling was carried out on gold properties in many of the mining areas. Exploration has been adversely affected in Ontario by the decline in the gold price and problems related to increasing inflation, government taxation policies, and the difficulty in raising venture capital.

Table 3. Canada, gold production, 1966-1975

	Auriferous Quartz Mines		Placer Operations		Base-metal ores		Total	
	(ounces)	(%)	(ounces)	(%)	(ounces)	(%)	(ounces)	(%)
1966	2,676,381	80.6	43,369	1.3	599,724	18.1	3,319,474	100
1967	2,426,137	81.2	9,411	0.3	550,720	18.5	2,986,268	100
1968	2,208,184	80.5	9,564	0.4	525,273	19.1	2,743,021	100
1969	2,030,680	79.8	8,725	0.3	505,704	19.9	2,545,109	100
1970	1,883,764	78.2	7,359	0.3	517,451	21.5	2,408,574	100
1971	1,766,634	78.2	4,988	0.2	489,108	21.6	2,260,730	100
1972	1,598,460	76.9	4,454	0.2	475,653	22.9	2,078,567	100
1973	1,416,842	72.5	9,804	0.5	527,694	27.0	1,954,340	100
1974	1,212,911	71.4	9,803	0.6	475,678	28.0	1,698,392	100
1975[p]	1,240,000	74.1	4,000	0.2	430,000	25.7	1,674,000	100

Source: Statistics Canada. Breakdown classification by Statistics Section, Mineral Development Sector, Department of Energy, Mines and Resources, Ottawa.
[p] Preliminary.

Table 4. Canada, gold production, average value per ounce and relationship to total value of all mineral production, 1966-1975

	Total Production	Total Value	Average Value per Ounce	Gold as Percentage of Total Value of Mineral Production
	(ounces)	($ Cdn.)	($ Cdn.)	(%)
1966	3,319,474	125,177,364	37.71	3.1
1967	2,986,268	112,731,618	37.75	2.6
1968	2,743,021	103,439,321	37.71	2.2
1969	2,545,109	95,925,158	37.69	2.0
1970	2,408,574	88,057,464	36.56	1.5
1971	2,260,730	79,903,241	35.34	1.3
1972	2,078,567	119,742,087	57.61	1.9
1973	1,954,340	190,376,168	97.41	2.3
1974	1,698,392	263,794,245	155.32	2.3
1975[p]	1,674,000	276,125,000[1]	165.03	2.1

Source: Statistics Canada.
[p] Preliminary.
[1] Value not necessarily based on average gold price for 1975.

Prairie Provinces. Virtually all gold produced in the prairie provinces was recovered as a byproduct from the mining of base-metal ores. A small amount of gold was recovered by gravel-washing plants on the North Saskatchewan River near Edmonton. A limited amount of exploratory work was done in some of the former gold-producing districts.

British Columbia. The major portion of gold produced in British Columbia in 1975 was recovered as a byproduct of base-metal mines, mainly from the treatment of copper ores. In August 1975 Dusty Mac Mines Ltd. started shipping ore from its open-pit gold mine in British Columbia to the mill of Dankoe Mines Ltd. for custom treatment. Proven reserves are 102, 000 tons grading 0.24 ounce of gold and 4.29 ounces of silver a ton. The milling contract called for 10,000 tons of ore a month. The concentrates produced were shipped to Cominco Ltd's smelter at Trail for the recovery of gold and silver. Northair Mines Ltd. was constructing a 300-ton-a-day mill at its gold-silver property at Brandywine Falls about 70 miles north of Vancouver and expected to start milling early in 1976. Some placer gold was recovered from the Cariboo and Atlin districts. Inflation and adverse taxation policies held exploration to a minimum in 1975.

Yukon Territory. There was considerable activity in the placer mining districts in the Yukon in 1975, especially in the Dawson area. A placer discovery was made in the Gold Range area near the Alaska boundary and about 60 miles north of Snag. Whitehorse Copper Mines Ltd. was the main contributor to byproduct gold production.

Northwest Territories. Cominco Ltd. continued the shaft-sinking program at its Con mine near Yellowknife and expected that the shaft will be completed to a depth of 5,800 feet in the latter half of 1976. In March, the company announced that the mill capacity will be increased from 450 tons to 650 tons a day in 1976.

Camlaren Mines, Limited completed an underground development program on its Gordon Lake property north of Yellowknife. Camlaren decided to defer mill construction because of escalating costs and the decline in the gold price. Giant Yellowknife Mines Limited started milling ore from its open-pit orebody. The company also carried out an underground exploration and surface diamond drill program on its optioned Salmita property, about 15 miles north of Yellowknife.

Foreign Developments

Republic of South Africa. In 1975, gold production in the Republic of South Africa was estimated at 22.8 million ounces compared with 24.4 million ounces in 1974, a decline of 6.5 per cent. The lower production was a result of labour shortages, labour disturbances and the treatment of lower grade ore to take advantage of the higher gold price during the first part of the year. The South African mines are highly labour-intensive and in the past have relied heavily on expatriate labour; Malawi and Mozambique being the two most important sources. A major setback to the labour pool was the banning of labour recruitment from Malawi by the government of that country. To offset the loss of the Malawian source of labour and to reduce dependence on foreign labour, the South African mine operators launched a campaign to recruit African miners from South Africa and by the end of July 1975 this labour source had increased to over 125,000 compared with 82,000 at the end of 1974. The largest proportion of the 350,000 African workers employed in the mines at the middle of 1975 were from South Africa. Today Mozambique and Lesotho are the major source of expatriate labour, but labour recruitments also come from Botswana and Rhodesia. Mining costs rose an estimated 25 per cent in 1975 because of increased cost of supplies and substantial wage increases to miners, which, coupled with the decline of the gold price in the second half of 1975, reduced the profitability of gold mines. The 17.9 per cent devaluation of the Rand in September 1975, primarily caused by the decrease in the gold price, eased some of the pressures on producers.

Gold output in South Africa is expected to remain relatively stable or show a slight decrease over the next three to four years. The South African operators are investigating ways for increased use of mechanized equipment to increase productivity, but the geological nature of the ore deposits and the narrow widths of the ore zones precludes the use of much of the equipment now available for stoping.

United States. Gold production in the United States was estimated at 1.03 million ounces in 1975 by the U.S. Bureau of Mines, a decline of 8.8 per cent from the 1.13 million ounces produced in 1974. Shortage of labour and lower copper production, the main source of byproduct gold, were largely responsible for the lower gold production. Lode gold mines accounted for about 59 per cent of the total output. The major lode gold producers were Homestake Mining Company in South Dakota, and Carlin Gold Mining Company and Cortez Gold Mines in Nevada. Kennecott Copper Corporation was the major contributor to byproduct gold. Higher gold prices in the first half of the year stimulated considerable mine exploration in many of the old gold-mining districts, especially in Nevada following the success of open-pit gold mines in that state. Some gold is being recovered in Nevada, New Mexico and Colorado by cyanide heap leaching on deposits that would not justify the expense of a conventional cyanide plant.

Table 5. Average annual price of gold, 1971-1975

	London Free Market[1]		Royal Canadian Mint[2]
	($ U.S.)	(equiv. $ Cdn.)	($ Cdn.)
1971	40.806	41.206	35.34
1972	58.132	57.531	36.60
1973	97.224	97.250	38.86
1974	159.259	155.320	41.18
1975[p]	161.055	165.025	43.22

[1]Annual averages of London Free Market Price, afternoon fixings, as reported by Sharps Pixley Ltd. [2]Annual averages of the Royal Canadian Mint Weekly published buying prices.
[p]Preliminary.

Dominican Republic. The Pueblo Viezo mine of Rosario Dominicana, S.A., located in the provinces of Sanchez Ramirez in the northern central region of the Dominican Republic, came into production on April 1, 1975. Rosario Dominicana is owned 40 per cent by Rosario Resources Corporation, 40 per cent by J.R. Simplot and 20 per cent by the Dominican Republic's central bank. The plant has been designed to treat 8,000 metric tons of ore a day from its open-pit mine, and annual output will be about 350,000 ounces of gold and 1,500,000 ounces of silver. At plant capacity the Pueblo Viezo mine will be the second largest gold producer in the western hemisphere. The doré bullion produced by the mine will be shipped to Switzerland for refining and marketing. Ore reserves are estimated at 30 million metric tons of oxide ore averaging 0.128 ounce of gold and 0.82 ounce of silver a metric ton. Drilling has also indicated a sulphide zone containing 17 million metric tons averaging 2.19 per cent zinc, 0.25 per cent copper, 0.131 ounce of gold and 1.12 ounces of silver a metric ton.

Australia. In Australia the Gold Mining Assistance Act 1954-1972 expired on June 30, 1975. The Act came into force on November 18, 1954 to assist the gold mines that were facing economic hardships by extending subsidy payments on gold production under certain terms.

Newmont Proprietary Limited, a wholly-owned subsidiary of Newmont Mining Corporation, has a 30 per cent interest in a gold mine in western Australia, with Dampier Mining Company Limited, a wholly-owned subsidiary of The Broken Hill Proprietary Company Limited, holding the other 70 per cent. It is estimated that plant construction, which is underway and is expected to be completed by 1977, will cost $36 million. Open-pit mineable reserves are estimated at 4,200,000 tons averaging 0.28 ounce of gold a ton.

The drop in the gold price and increased production costs have made many of the Australian mines marginal and closures have taken place in 1975. If there is no improvement in the gold price more mines will be forced to close in 1976.

Bolivia. Camino Gold Mines Limited, a Canadian company, carried out a limited amount of exploratory work on its placer gold deposit in the Tipuani Valley district.

Brazil. The Anglo American Corporation of South Africa Ltd. has purchased 49 per cent of Brazil's major gold mining operation. The Mineracao Morro Velho, S.A., near Belo Horizonte in Minas Gerais state. Anglo American's expertise and financial resources will be used to increase efficiency and productivity at the mine. About 50 per cent of Brazil's gold production of over 400,000 ounces comes from this property.

Costa Rica. Esperanza Mines Corporation, wholly-owned subsidiary of Bulora Corporation Limited, a Canadian company, operated a small gold mill at its Libana gold mine.

Nicaragua. Noranda Mines Limited holds a 60.5 per cent interest in the Empresa Minera de el Setentrion, a gold property in Nicaragua. In 1975, 59,400 ounces of gold were recovered from this mine from the treatment of 129,900 tons averaging 0.5 ounces of gold a ton.

Philippines. In the Philippines incentives have been extended to gold mines by the government through long-term credit facilities to help finance exploration and development, tax exemption on the import of mining and milling facilities for exploration, and development and technical assistance by the Bureau of Mines to newly developed mines. These incentives

(text continued on page 218)

Table 6. Principal gold (mine) producers in Canada, 1975 and (1974)

Company and Location	Mill or Mine Capacity	Grade of Ore Produced: Gold	Silver	Copper	Combined Lead & Zinc	Ore Treated	Gold Produced	Remarks
	(tons of ore/day)	(oz/ton)	(oz/ton)	(%)	(%)	(tons)	(oz)	
Newfoundland								
ASARCO Incorporated (Buchans Unit) Buchans	1,250 (1,250)	0.022 (0.024)	3.03 (3.25)	0.95 (1.01)	16.46 (17.52)	232,000 (264,000)	4,085 (5,106)	
Consolidated Rambler Mines Limited Baie Verte	1,200 (1,200)	0.06 (0.06)	0.57 (0.57)	3.20 (3.16)	— (—)	244,562 (215,541)	10,463 (9,047)	Boundary shaft completed.
New Brunswick								
Heath Steele Mines Limited Newcastle	3,100 (3,100)	0.018 (0.018)	1.73 (1.98)	1.03 (1.04)	5.63 (6.11)	1,089,443 (1,085,495)	5,769 (5,770)	Mill expansion to 4,000 tpd completed, work continuing on No. 5 production shaft.
Quebec								
Agnico-Eagle Mines Limited Joutel	1,000 (1,000)	0.233 (0.250)	. . (.)	— (—)	— (—)	309,524 (194,702)	59,224 (31,079)	Mill circuit altered to improve recovery; shaft to be deepened 1,100 ft to 2,965 depth.
Camflo Mines Limited Malartic	1,250 (1,000)	0.194 (0.216)	. . (.)	— (—)	— (—)	456,123 (377,521)	88,568 (81,589)	Shaft deepening program and mill expansion to 1,250 tons completed, driving ore and waste passes.
Campbell Chibougamau Mines Ltd. Main, Cedar Bay and Henderson Mines Chibougamau	4,000 (4,000)	0.054 (0.024)	0.229 (0.220)	1.31 (1.03)	— (—)	219,543 (960,552)	. . (19,088)	Operations temporarily suspended in 1975.
East Malartic Mines, Limited Malartic	1,800 (1,800)	0.1024 (0.099)	. . (.)	— (—)	— (—)	561,278 (516,711)	55,335 (49,248)	Deepening of Barnet shaft by 600 ft. completed. Intensive maintenance program completed.

Table 6 (cont'd)

Company and Location	Mill or Mine Capacity	Grade of Ore Produced: Gold	Grade of Ore Produced: Silver	Grade of Ore Produced: Copper	Grade of Ore Produced: Combined Lead & Zinc	Ore Treated	Gold Produced	Remarks
	(tons of ore/day)	(oz/ton)	(oz/ton)	(%)	(%)	(tons)	(oz)	
Quebec (Cont'd.)								
Falconbridge Copper Limited Lake Dufault Division Millenbach and Norbec mines Noranda-Rouyn	1,500 (1,500)	0.023 (0.019)	1.12 (0.99)	2.50 (2.38)	3.35 (3.54)	560,775 (553,187)	8,865 (7,566)	Sinking Corbet shaft.
Falconbridge Copper Limited, Opemiska Division Perry, Springer and Cooke mines Chapais	3,000 (3,000)	. . (.)	0.33 (0.32)	2.02 (1.85)	— (—)	952,000 (927,059)	10,000 (8,796)	Cooke shaft completed to a depth of 1,985 ft.
Lamaque Mining Company Limited Val d'Or	2,100 (2,100)	0.124 (0.115)	. . (.)	— (—)	— (—)	476,310 (498,190)	55,532 (53,734)	Developing "flats" in north end of property.
Noranda Mines Limited Horne Division Noranda	3,200 (3,200)	0.148 (0.158)	— (0.59)	2.36 (2.8)	— (—)	282,259 (390,000)	32,458 (40,761)	Ore reserves will be exhausted in 1976.
Patino Mines (Quebec) Limited Chibougamau	2,800 (2,800)	0.057 (0.043)	0.248 (0.200)	1.67 (1.56)	— (—)	440,000 (859,000)	20,000 (31,000)	Lemoine Mine began production in 1975.
Sigma Mines (Quebec) Limited Val d'Or	1,400 (1,400)	0.152 (0.153)	. . (.)	— (—)	— (—)	497,428 (498,410)	72,676 (73,019)	Ore passes being driven on lower levels.
Ontario								
Bulora Corporation Limited Madsen Red Lake Division Red Lake	800 (800)	0.217 (0.257)	. . (.)	— (—)	— (—)	137,718 (90,127)	28,246 (22,195[1])	Fiscal year ending Sept. 30, 1975.
Campbell Red Lake Mines Limited Red Lake	800 (800)	0.671 (0.743)	. . (.)	— (—)	— (—)	299,560 (299,833)	185,228 (197,369)	

Dickenson Mines Limited Red Lake	470 (470)	0.431 (0.388)	0.04 (. .)	— (—)	— (—)	91,382 (105,563)	36,537 (37,640)	Installing dust collecting system to recover calcine and arsenic trioxide.
Dome Mines Limited South Porcupine	1,900 (1,900)	0.170 (0.178)	. . (. .)	— (—)	— (—)	708,000 (701,600)	117,089 (121,032)	
Falconbridge Copper Limited, Sturgeon Lake Division Sturgeon Lake	1,200 (1,200)	0.018 (. .)	5.31 (4.58)	2.78 (2.05)	10.24 (8.68)	376,682 (83,000)	3,000 (. .)	First full year of production.
Falconbridge Nickel Mines Limited Ontario mines, Sudbury district	12,100 (12,100)	. . (. .)	. . (. .)	. . (. .)	— (—)	3,012,005 (4,337,000)	. . (. .)	Operations reduced to 70% in November 1975.
Hollinger Mines Limited Ross mine Holtyre	450 (450)	0.136 (0.13)	. . (. .)	— (—)	— (—)	124,329 (124,231)	16,891 (16,414)	Carrying out exploration program on adjoining New Kelore mine.
International Nickel Company of Canada, Limited (The) Sudbury & Shebandowan districts, Ontario; and Thompson, Manitoba	85,900 (85,900)	. . (. .)	. . (. .)	1.09 (0.97)	— (—)	21,000,000 (22,000,000)	. . (. .)	Nickel deliveries reduced.
Kerr Addison Mines Limited Virginiatown	741[2] (760)[2]	0.39 (0.40)	. . (. .)	— (—)	— (—)	270,000 (277,000)	102,770 (108,820)	Some low grade ore recovered from shrinkage stope.
Mattabi Mines Limited Sturgeon Lake	3,000 (3,000)	. . (. .)	3.23 (4.31)	0.97 (0.91)	8.04 (9.72)	1,074,923 (1,138,965)	3,776 (5,467)	Development of underground portion of ore-body begun.
Pamour Porcupine Mines, Limited Nos. 1, 2 & 3 mines Pamour	3,000 (2,500)	0.116 (0.115)	. . (. .)	— (—)	— (—)	903,964 (859,525)	99,504 (91,571)	Treated some ore from open-pit zone.
Pamour Porcupine Mines, Limited, Schumacher Division (gold) Schumacher	1,500 (1,500)	0.180 (0.201)	. . (. .)	— (—)	— (—)	211,242 (214,130)	35,261 (39,508)	Gold sector of mine.
Pamour Porcupine Mines, Limited, Schumacher Division (copper) Schumacher	2,000 (2,000)	0.027 (0.023)	0.107 (0.105)	0.619 (0.628)	— (—)	684,680 (706,940)	14,807 (12,183)	Copper sector of mine.

Table 6 (cont'd)

Company and Location	Mill or Mine Capacity	Grade of Ore Produced: Gold	Silver	Copper	Combined Lead & Zinc	Ore Treated	Gold Produced	Remarks
	(tons of ore/day)	(oz/ton)	(oz/ton)	(%)	(%)	(tons)	(oz)	
Ontario (cont'd)								
Robin Red Lake Mines Limited Red Lake	96[2] (124)[2]	0.712 (0.730)	0.04 (.)	— (—)	— (—)	34,925 (45,446)	23,094 (30,454)	Ore mined and milled by Dickenson.
Willroy Mines Limited, Macassa Division Kirkland Lake	500 (500)	0.529 (0.508)	. . (.)	— (—)	— (—)	88,008 (90,186)	44,510 (43,611)	Continued to explore potentially favourable ground.
Manitoba-Saskatchewan								
Hudson Bay Mining and Smelting Co., Limited Flin Flon and Snow Lake districts	8,500 (8,500)	0.030 (0.035)	0.60 (0.63)	2.40 (2.34)	3.20 (3.34)	1,470,157 (1,574,948)	33,998 (50,342)	Shaft sinking program at Centennial mine completed.
Sherritt Gordon Mines Limited Fox mine Lynn Lake	3,000 (3,000)	. . (.)	. . (.)	1.74 (2.10)	1.81 (1.98)	1,007,183 (1,008,000)	. . (.)	Gold sales in 1975 25,000 ounces.
Sherritt Gordon Mines Limited Ruttan mine Ruttan	10,000 (10,000)	. . (.)	. . (.)	0.96 (1.07)	1.90 (1.68)	3,340,794 (3,358,000)	. . (.)	
British Columbia								
Dusty Mac Mines Ltd. (N.P.L.) Okanagon Falls	. .	0.188	4.23	—	—	44,027	7,698	Open pit, ore custom-treated at Dankoe mill.
Granby Mining Corporation Granisle mine Babine Lake	13,000 (13,000)	. . (.)	0.04 (.)	0.44 (0.46)	— (—)	4,879,623 (4,853,434)	16,966 (18,369)	Data for fiscal year ending Sept. 30.
Granby Mining Corporation Phoenix mine Greenwood	2,750 (2,750)	0.017 (0.017)	0.175 (0.134)	0.49 (0.44)	— (—)	1,073,512 995,751	11,171 10,003	Data for fiscal year ending Sept. 30.

Granduc Operating Company Stewart	8,000 (8,000)	— (0.004)	— (0.216)	1.20 (1.23)	— (—)	1,653,000 (2,708,731)	5,232 (9,803)	Production reduced 50% in 1975.
Noranda Mines Limited Bell Copper Division Babine Lake	10,000 (10,000)	. . (. .)	. . (. .)	0.46 (0.524)	— (—)	4,778,598 (4,500,998)	23,760 (28,700)	Concentrates shipped to Horne Smelter Noranda, Quebec.
Similkameen Mining Company Limited Ingerbelle pit Princeton	22,000 (15,000)	. . (. .)	. . (. .)	0.46 (0.48)	— (—)	4,072,000 (5,086,000)	21,400 (29,100)	Mill expansion completed.
Utah Mines Ltd. Island Copper Mine Coal Harbour Vancouver Island	38,000 (38,000)	. . (. .)	. . (. .)	0.48 (0.47)	— (—)	13,300,000 (11,200,000)	60,000 (45,000)	
Western Mines Limited, Buttle Lake Vancouver Island	1,100 (1,100)	0.08 (0.09)	4.49 (4.52)	1.12 (1.28)	8.93 (9.53)	287,393 (297,290)	20,669 (23,189)	Increased percentage of ore from underground.
Yukon Territory								
Whitehorse Copper Mines Ltd. Whitehorse	2,400 (2,400)	0.025 (0.028)	0.295 (0.346)	1.52 (1.84)	— (—)	738,062 (17,841)	18,630 (17,731)	Installation of underground crusher improved hoisting efficiency.
Northwest Territories								
Cominco Ltd. Con & Rycon mines Yellowknife	500 (500)	0.55 (0.60)	. . (. .)	— (—)	— (—)	148,000 (145,000)	77,300[e] (82,650)[e]	New shaft to 5,800 ft., concentrator expansion, expected to be completed late in 1976.
Giant Yellowknife Mines Limited Yellowknife	1,000 (1,000)	0.271 (0.32)	. . (. .)	— (—)	— (—)	341,761 (254,918)	81,246 (71,095)	25 per cent of ore treated from open-pit mine.
Lolor Mines Limited Yellowknife	50[2] (70)[2]	0.265 (0.286)	. . (. .)	— (—)	— (—)	18,338 (25,460)	4,270 (6,367)	Ore mined and milled by Giant Yellowknife
Supercrest Mines Limited Yellowknife	87[2] (131)[2]	0.463 (0.578)	. . (. .)	— (—)	— (—)	31,870 (47,721)	12,921 (24,052)	Ore mined and milled by Giant Yellowknife

Source: Company reports.
[1]Eight and one-half month's production. [2]Average daily tonnage milled.
[e]Estimated; — Nil; . . Not available.

have generated increased activity in the gold mining industry, and the possibilities of bringing new mines into production and increasing output at producing mines are being investigated.

U.S.S.R. Accurate data on the gold mining industry in the U.S.S.R. is not available. A significant amount of gold is recovered from placer operations. Gold is also recovered from lode mines and as a byproduct from base-metal mines. Gold production in the U.S.S.R. is expected to increase in 1976.

Price

The price of gold on the London Gold Market closed at $140.25 (U.S.) an ounce at the end of 1975, a decline of 24 per cent from the year-opening price of $185 U.S. an ounce. The average of the afternoon fixing prices on the London Market for the year 1975 was $161.018 U.S. compared with $159.259 U.S. an ounce in 1974.

Four factors played a key role in determining the gold price pattern for 1975; the lack of interest in the purchase of gold by the United States public; the decision by the United States government to offer for auction two million ounces of gold from its official reserves; an improvement in the United States trade balance and a strengthening of the U.S. dollar relative to other currencies.

On and after December 31, 1974 the United States citizens were allowed to buy, sell and hold gold after being prohibited from trading in gold for 41 years, unless holding a licence issued by the U.S. government. There was widespread expectation of a massive rush by American citizens to buy gold and the price of gold in anticipation of this demand began a sharp rise in November 1974, reaching a high of $197.50 an ounce on December 30, 1974. The rush never developed. United States citizens showed little interest in acquiring gold and the price rise peaked. The high level of the gold price and brokerage charges and taxes did much to discourage the development of an active interest.

At the first United States gold auction on January 6, 1975 the United States Treasury made available from its official reserves 2 million ounces of gold for competitive bidding. The sale generated little interest and bids were accepted on only 754,000 ounces ranging in price from $153 U.S. an ounce to $181 and averaging $165.67. This average was below the free market price of $169.50 on January 7, 1975, but prices quickly recovered and remained in the range of $186 to $171 until April 14 when the price declined to $167.50.

Following the agreement reached in December 1974 in Martinique between U.S. President Gerald Ford and French President Valery Giscard d'Estaing, regarding the use of the free market gold price for the evaluation of official gold reserves, the French government revalued its gold reserves early in January 1975, based on a price of $170.40 U.S. an ounce. This action by the French government had little effect, if any, on the stabilization of the gold price near this level. In July 1975, France adjusted its reserve value in gold by adjusting the value of gold to $171.36 U.S. an ounce and it remained at this level for the remainder of the year.

At the second United States Treasury gold auction held on June 30, 1975, 449,500 ounces of gold were sold to all successful bidders at a price of $165.05 an ounce, a free market-related price at that time, and close to the average price at the first auction.

For the period from mid-April, 1975 to the end of August the free market gold price, with minor fluctuations, remained relatively close to the bid price of just over $165 U.S. obtained at both U.S. gold auctions. For a short period in mid-May the gold price was over $170 U.S. an ounce because of unsettled world conditions.

On August 31, the Interim Committee of the International Monetary Fund (IMF) announced that an agreement had been reached: to abolish the official price of gold, for the sale of about one sixth (25 million ounces) of gold from the Fund's official reserves to establish a fund, with the profits derived from the sale, to assist developing countries; and for the restitution of one-sixth of the Fund's gold to member countries in proportion to their holdings in the Fund. Unresolved at the Interim Committee's meeting was an acceptable solution on the exchange rate system to be adopted. This issue will be on the agenda at the next Interim Committee meeting in Jamaica in early January 1976. To be effective the agreement reached on the role of gold in future monetary arrangements depends on a resolution of the problems relating to the exchange rate system.

The decision of the IMF to sell gold severely affected the gold market. On September 1, 1975 the price had dropped to $154.25 an ounce on the London Market from the preceding day's afternoon fixing price of $159.80 U.S. an ounce. The market price for gold fell to $128.75 on September 23 which was not only the lowest price quoted on the London Market for 1975 but the lowest price since January 1974. Gold recovered from this low, and held in a price range slightly above or below $140.00 U.S. for the remainder of the year.

A factor of major importance in the pricing of gold will be the arrangements made by central banks of the different countries involved to treat the large amount of gold now in their official reserves once the official price of gold is removed in about one and one-half to two years. At the end of 1975 gold in official reserves of the noncommunist countries was 1.1781 billion ounces compared with 1.1794 billion ounces at the end of 1974. Gold in official reserves held by each country is shown in Table 7. A small percentage of this gold made available to the free market would put severe downward pressure on the pricing pattern, and it is not likely that the central banks will make any large sales. In 1974, Italy borrowed $2 billion from West Germany, using the collateral value of gold in its reserves to secure the loan. Details of the loan were not announced but an unofficial report placed the value of the gold in the range of $120.00 U.S. an ounce. In mid-1975 Portugal obtained a short-term credit from the Bank for International Settlements using part of their gold reserves as collateral. It would appear that gold now in official reserves of central banks will be used to a greater extent as collateral for loans once official price restrictions are removed.

Table 7. Gold reserves of central banks and governments, December 31, 1975

Country	Value in millions of dollars; gold valued at $42.22 U.S. per fine ounce	ounces (fine) in millions of ounces
United States	11,599	274.7
West Germany	4,966	117.6
France	4,262	100.9
Switzerland	3,513	83.2
Italy	3,483	82.5
Netherlands	2,294	54.3
Belgium	1,781	42.2
Portugal	1,170	27.7
Canada	927	22.0
Japan	891	21.1
United Kingdom	888	21.0
Austria	882	20.9
South Africa	749	17.8
Spain	602	14.3
Others	5,009	118.7
International Monetary Fund	6,478	153.4
Bank for International Settlements	246	5.8
Estimated total, world[1]	49,740	1,178.1

Source: Value from *Federal Reserve Bulletin* (US) May 1976; number of ounces calculated by Mineral Development Sector, Department of Energy, Mines and Resources, Ottawa.
[1]Excludes holdings of the U.S.S.R., other Eastern European Countries and the People's Republic of China.

Uses and consumption

Gold has been used traditionally as a monetary reserve by governments and central banks in the settlement of international balances, but since August 1971, when the President of the United States temporarily suspended the convertibility of the U.S. dollar into gold, it has not been used for the settlement of balance payments. When the accord reached August 31, 1975, on abolishing the official price of gold is finalized, the metal's use as an official reserve will disappear.

The major industrial uses of gold are in the jewellery trade, the electronic industry, dentistry, coinage, and in fabricating medallions. In jewellery products, because of the high gold price, the trend is towards the fabrication of items having a lower carat gold content. In the industrial field, emphasis has been placed on the development of technology leading to a more efficient use of gold, such as a thinner film in gold-plating, selective and spot gold-plating, and duplex plating with a high-carat surface on a low-carat base. Other precious metals; silver, platinum and palladium, can replace gold in many of its usages.

According to figures contained in the Consolidated Gold Fields report the noncommunist world consumption of gold in 1975 increased substantially for jewellery, declined in the electronic industry and in other industrial and decorative uses, and increased in dentistry and in the fabrication of gold medals and medallions. World consumption of gold in the noncommunist world was estimated at 36.17 million ounces in 1975 compared with 40.32 million ounces in 1974.

Gold consumed in the jewellery industry in 1975 was estimated at 17.1 million ounces compared with 7.4 million ounces in 1974. Italy, Spain and Turkey registered substantial increases in the fabrication of jewellery. Italy's strong demand was to satisfy a strong export market. Most other countries in Europe had smaller gains. Substantial improvements in jewellery demand also took place in India, the Arab countries and South East Asia. In 1974, many of the Arab countries un-hoarded gold contained in jewellery and as a result had a negative consumption in jewellery. In the United States gold usage in the fabrication of jewellery continued the decline with began in 1973. Consumption was estimated at 2.06 million ounces, a decline of 17 per cent from 1974. Demand for jewellery in the U.S. improved towards the end of 1975 because of the lower gold price.

The high price of gold in 1974 and the first part of 1975 led to the development of technological improvements in the use of gold and to substitution by other materials in the electronics industry, and the consumption of gold in this field in the noncommunist world declined from 3.05 million ounces in 1974 to 2.09 million ounces in 1975. Consumption of gold in the electronics industry in the United States, the world's largest gold consumer in 1975 was 656,000 ounces, a decline of 53.6 per cent. Gold used in dentistry in the noncommunist world in 1975 was estimated at 2.09 million, slightly above the 1974 figure.

The strong demand for official gold coins that developed in 1974 continued in 1975 but at a reduced rate. Gold used in the minting of coins in 1975 was estimated at 7.1 million ounces compared with 9.15 million ounces in 1974. In both years by far the largest amount of gold was used in the minting of the Krugerrand, a South African coin containing one ounce of gold. Sales of this coin in 1975 amounted to 4.80 million ounces, over two-thirds of the world coin total. The major outlets for the Krugerrand were West Germany, accounting for about 50 per cent of the sales and the United States. The premium on the sale of the

Krugerrand is about 3 per cent, lower than that charged for other gold coins, wafers or bars. These coins were also in demand in the United Kingdom, but on April 15, 1975 the British government placed a ban on the importation of gold coins, medallions and gold medals to reduce the drain on the United Kingdom's balance of payments. Citizens of the United Kingdom are prohibited from holding gold bullion. The Royal Mint in the United Kingdom used about 0.7 million ounces in striking the new issues of Queen Elizabeth sovereigns which were sold mainly in Italy and the Middle East. The minting of the Mexican Peso and Austrian Ducat dropped sharply in 1975 mainly because of competition from the Krugerrand.

The U.S.S.R. entered the gold coin market with the minting of about 250,000 chervonetz coins, a coin containing about one-quarter ounce of gold, for sale to investors and collectors, mainly in the United States and West Germany.

Outlook

The meeting of the Twenty Finance Ministers of the International Monetary Funds Interim Committee held in Jamaica on January 7-8, 1976, reached an agreement on all aspects of a major international monetary package. At the meeting it was agreed that an immediate start should be made on the sale of 25 million ounces from the IMF's official reserves over a four-year period. The result of this agreement was a further deterioration in the gold price and it fell from a price range of $140 U.S. to a range of $130 U.S. an ounce. The release of large quantities of gold to the market over relatively short periods will prevent any sharp upward moves in the gold price under the present market structure. It will probably have the reverse effect and lead to a softening of the market. About 30 per cent of 25 million ounces of gold to be restituted to member countries by the Fund over a four-year period will go to the developing countries and part or all of this gold could be offered to the market by these countries to obtain needed foreign exchange. Sales of gold by the U.S.S.R. to obtain foreign currency, the possibility of sales by the U.S. Treasury and the necessity of the Republic of South Africa to sell its gold production to meet balance-of-payment deficits will place further downward pressures on the gold market. All the above unfavourable factors indicate that in the short-term view it is unlikely that the gold price will make any sharp recovery to the levels existing in the first half of 1975. A positive factor is the possibility of large purchases of the IMF gold by central banks when the present restrictions on adding to their official reserves through free market purchases are removed in about two years. Such purchases of IMF gold by central banks would reduce the quantity of gold coming on the open market and would likely result in stronger gold prices.

In the short-term outlook gold production in the noncommunist world is expected to decline. The low gold price will force the closure of some mines and the postponement of bringing prospective producers into production. The Republic of South Africa is by far the leading gold producer in the world, and its gold output has a strong impact on noncommunist world gold production. Production in South Africa should decline slightly because of the unsettled labour situation. Three new mines are under development, but are not expected to contribute to output for three to four years. Improvements in base-metal output should result in a slight increase in byproduct gold but would not be sufficient to offset lode mine decline.

Gold production in Canada will continue its downward trend. The sharp drop in the gold price towards the end of 1975 and early 1976 will cause some marginal gold producers to discontinue operations. Few mines in Canada can offset lower production by mining higher grade ore. Many of the active exploration and development programs were discontinued pending an improvement in the gold market. Gold recovered from base-metal ores is expected to remain near the 1975 level.

The supply of newly mined gold is more than adequate to meet the industrial and commercial demand for the metal. Its use in the electronic industry and dentistry is expected to increase slightly. The use of gold in jewellery and decorative art is closely related to price and at the present low price level consumption in these applications are expected to increase substantially.

Gold Producers 1975
(numbers refer to numbers on the map)

Newfoundland

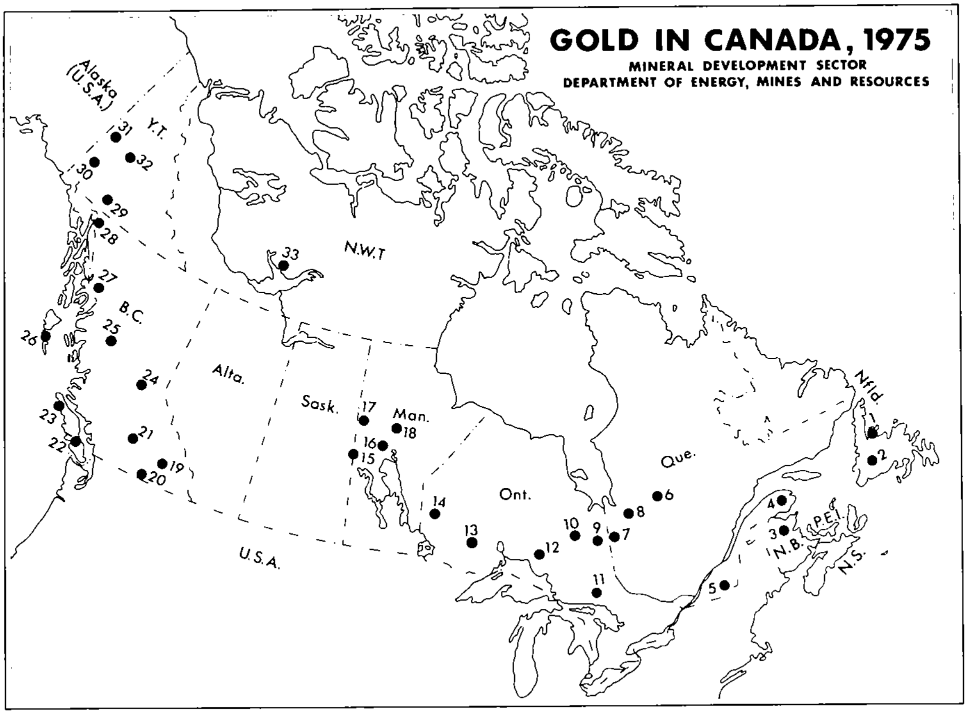
(1) Consolidated Rambler Mines Limited (a)*
(2) ASARCO Incorporated
(Buchans Unit) (a)

New Brunswick

(3) Heath Steele Mines Limited (a)

Quebec

(4) Gaspé Copper Mines, Limited (a)
(5) Sullivan Mining Group Ltd. (a)
(6) Chibougamau district
Campbell Chibougamau Mines Ltd. (a)
Falconbridge Copper Limited (Opemiska Division) (a)
Patino Mines (Quebec) Limited (Copper Rand Division) (a)
Valley Mining Corp. (Chibex Limited mine) (a & b)
(7) Noranda-Rouyn district
Falconbridge Copper Limited (Lake Dufault Division) (a)
Noranda Mines Limited (a)
Duparquet district
Kerr Addison Mines Limited (Normetal) (a)
Malartic district



Quebec (cont'd)

Camflo Mines Limited (b)
East Malartic Mines, Limited (b)
Bourlamaque-Louvicourt district
La Société minière Louvem inc. (a)
Lamaque Mining Company Limited (b)
Manitou-Barvue Mines Limited
Sigma Mines (Quebec) Limited (b)

(8) Matagami district
Agnico-Eagle Mines Limited (b)
Mattagami Lake Mines Limited (a)
Orchan Mines Limited (a)

Ontario

(9) Larder Lake Mining Division
Hollinger Mines Limited (Ross) (b)
Kerr Addison Mines Limited (b)
Willroy Mines Limited (Macassa Division) (b)

(10) Porcupine Mining Division
Dome Mines, Limited (b)
The Mining Corporation of Canada, Limited (New Joburke mine) (b)
Pamour Porcupine Mines, Limited (Nos. 1, 2 & 3 mines) (b)
Pamour Porcupine Mines, Limited (Schumacher Division, McIntyre Mines) (a & b)

(11) Sudbury Mining Division,
Falconbridge Nickel Mines Limited (a)
The International Nickel Company of Canada, Limited (a)

(12) Thunder Bay Mining Division
Noranda Mines Limited (Geco Mine) (a)

(13) Patricia Mining Division
Falconbridge Copper Limited (Sturgeon Lake Division) (a)
Mattabi Mines Limited (a)

(14) Red Lake Mining Division
Bulora Corporation Limited (Madsen Red Lake Division) (b)
Campbell Red Lake Mines Limited (b)
Dickenson Mines Limited (b)
Robin Red Lake Mines Limited (b)

Manitoba

(15) Hudson Bay Mining and Smelting Co., Limited (Flin Flon) (a)

(16) Hudson Bay Mining and Smelting Co., Limited (Snow Lake) (a)

(17) Sherritt Gordon Mines Limited (Fox Lake & Ruttan mines) (a)

(18) The International Nickel Company of Canada, Limited (Thompson) (a)

Saskatchewan

(15) Hudson Bay Mining and Smelting Co., Limited (a)

British Columbia

(19) Cominco Ltd. (a)
(20) Granby Mining Corporation (Phoenix Division) (a)
Dusty Mac Mines Ltd. (N.P.L.) (b)
(21) Brenda Mines Ltd. (a)
Similkameen Mining Company Limited (a)
(22) Western Mines Limited (a)
(23) Utah Mines Ltd. (Island Copper Mine) (a)
(24) Small placer operations (c)
(25) Granby Mining Corporation (Granisle Division) (a)
Noranda Mines Limited (Bell Copper) (a)
(26) Wesfrob Mines Limited (a)
(27) Granduc Operating Company (a)
(28) Small placer operations (c)

Yukon Territory

(29) Whitehorse Copper Mines Ltd. (a)
(30) Small placer operations (c)
(31) Small placer operations (c)
(32) Small placer operations (c)

Northwest Territories

(33) Cominco Ltd. (Con mine) (b)
Giant Yellowknife Mines Limited (b)
Lolor Mines Limited (b)
Rycon Mines Limited (b)
Supercrest Mines Limited (b)

---

*Footnote: (a) Base metal; (b) Auriferous quartz; (c) Placer.

Gypsum and Anhydrite

D.H. STONEHOUSE

Gypsum is a hydrous calcium sulphate ($CaSO_4.2H_2O$) which, when calcined at temperatures ranging from 250° to 400°F, releases three-quarters of its chemically-combined water. The resulting hemihydrate of calcium sulphate, commonly referred to as plaster of paris, when mixed with water, can be moulded, shaped or spread and subsequently dried, or set, to form a hard plaster product. Gypsum is the main mineral constituent in gypsum wallboard, lath and tile. Anhydrite, the anhydrous calcium sulphate ($CaSO_4$), is commonly associated geologically with gypsum.

Crude gypsum is crushed, pulverized and calcined to form stucco, which is mixed with water and aggregate (sand, vermiculite or expanded perlite) and applied over wood, metal or gypsum lath to form interior wall finishes. Gypsum board, lath and sheathing are formed by introducing a slurry of stucco, water, foam, pulp and starch between two unwinding rolls of absordent paper, which results in a continuous "sandwich" of wet board. As the stucco hardens, the board is cut to predetermined lengths, dried, bundled and stacked for shipment.

Keene's cement is made by converting crushed gypsum to insoluble anhydrite by calcining at temperatures as high as 1300°F, usually in rotary kilns. The ground calcine, mixed with a set accelerator, produces a harder and stronger plaster product than ordinary gypsum plaster.

Crude gypsum is also used in the manufacture of portland cement, acting as a retarder to control set. It is used as a filler in paint and paper manufacture, as a substitute for saltcake in glass manufacture and as a soil conditioner.

Technological developments have enabled the economic utilization of phosphogypsum, a calcium sulphate byproduct of phosphate fertilizer manufacture, in some European countries and in Japan. Great quantities of phosphogypsum are accumulating in both the United States and Canada in regions where disposal costs could encourage its use in gypsum products.

Production of gypsum in Canada is closely related to activity in the building construction industry, particularly to activity in the residential building sector in both Canada and the eastern United States. Between 70 and 75 per cent of Canadian gypsum production normally has been exported to the United States. During the recent period of economic recession, which seems to have bottomed out near the end of 1975 in the United States, exports were reduced to the lowest level since 1967. Canadian consumption has remained reasonably steady during the past four years at slightly over 2 million tons. Most of the gypsum for export is quarried in Nova Scotia and Newfoundland by Canadian subsidiaries of United States gypsum products manufacturers. Although most of the output from other provinces is used regionally, nearly all the Nova Scotia production is exported in large "in-company" shipments to the eastern United States.

Total construction in Canada in 1975 is estimated to have reached a value of over $27 billion, 60 per cent of which is credited to the building construction sector. Traditionally, one half of building construction expenditures are in the residential category where, in 1975, housing starts were increased by 4 per cent to 231,456 units.

Production of gypsum wallboard, lath and sheathing increased slightly in 1975. Plaster production decreased by over 16,000 tons to 89,000 tons. The problem of material shortages within the construction industry which was evident in 1974 was not so predominant during 1975. A continuation of hesitant and cautious commitments by the construction industry was not alleviated by the creation of the Anti-Inflation Board in late 1975.

Canadian industry and developments

Atlantic provinces. During 1975, five companies produced crude gypsum in Nova Scotia, two in New Brunswick and one in Newfoundland. Consumption of raw gypsum in the Atlantic provinces was small compared with the quantity exported to the United States. Three cement manufacturing plants, two gypsum wallboard manufacturing plants and one plant producing plaster of paris, together used only about 100,000 tons. Crude gypsum from Nova Scotia is used by Quebec wallboard plants and by Quebec and Ontario cement

Table 1. Canada, gypsum production and trade, 1974-75

	1974		1975[p]	
	(short tons)	($)	(short tons)	($)
Production (shipments)				
Crude gypsum				
Nova Scotia	5,899,350	15,495,506	4,406,000	12,490,000
Ontario	774,398	2,783,539	742,000	2,620,000
British Columbia	441,299	1,412,157	450,000	2,214,000
Newfoundland	555,834	1,859,404	508,000	1,964,000
New Brunswick	86,816	305,309	59,000	230,000
Manitoba	206,726	581,451	90,000	202,000
Total	7,964,423	22,437,366	6,255,000	19,720,000
Imports				
Crude gypsum				
Mexico	19,417	77,000	43,100	448,000
United States	42,398	418,000	17,834	219,000
United Kingdom	179	17,000	55	4,000
West Germany	—	—	11	1,000
Hong Kong	12	1,000	—	—
Total	62,006	513,000	61,000	672,000
Plaster of paris and wall plaster				
United States	16,356	1,202,000	21,203	1,851,000
United Kingdom	496	31,000	490	24,000
Italy	—	—	20	2,000
Other countries	15	3,000	8	. .
Total	16,867	1,236,000	21,721	1,877,000
Gypsum lath, wallboard and basic products	sq.ft.		sq.ft.	
United States	148,414,378	6,216,000	109,813,793	4,818,000
Total	148,414,378	6,216,000	109,813,793	4,818,000
Total imports gypsum and gypsum products		7,965,000		7,367,000
Exports				
Crude gypsum				
United States	5,685,005	13,771,000	4,052,400	11,340,000
Bahamas	60,715	122,000	16,976	41,000
Total	5,745,720	13,893,000	4,069,376	11,381,000

Source: Statistics Canada.
[p] Preliminary; — Nil; . . Less than $1,000.

producers, each supplying regional construction industries.

Fundy Gypsum Company Limited, a subsidiary of United States Gypsum Company, Chicago, mines gypsum by open-pit methods at Wentworth and at Miller Creek near Windsor, Nova Scotia, for export to the United States. Crushed and beneficiated crude gypsum is shipped to company-owned processing plants through the port of Hantsport, Nova Scotia.

National Gypsum (Canada) Ltd. produces gypsum from a quarry near Milford, Nova Scotia, and exports most of it through the port of Halifax to east coast United States plants operated by the parent company, National Gypsum Company of Buffalo, New York. Unit-trains of 40 cars each are used to haul gypsum from the quarry site 30 miles to Dartmouth. Company-owned, self-unloading ore carriers of up to 30,000 tons capacity are loaded at rates as high as 5,000 tons an hour through facilities on Bedford Basin. Shipments are made by water to Quebec for use in the manufacture of gypsum products and cement, and by truck to Brookfield, Nova Scotia for use in cement manufacture.

Georgia-Pacific Corporation, Bestwall Gypsum Division, mines gypsum from a quarry near River Denys, Inverness County, Nova Scotia. The crushed rock is transferred by rail to open storage at Point Tupper, 20 miles from the quarry, and loaded on chartered vessels through a conveyor and reclaim tunnel system. Shipments are exported mainly to the Georgia-Pacific plant at Wilmington, Delaware.

Little Narrows Gypsum Company Limited, another subsidiary of United States Gypsum Company, produces gypsum from a quarry at Little Narrows, Victoria County, Nova Scotia, for shipments to the United States, Quebec and Ontario, through company shiploading facilities near the plant site.

Domtar Construction Materials Ltd. operates a calcining plant at Windsor, Nova Scotia, for the production of plaster of paris. Gypsum for the plant is supplied from a quarry at MacKay Settlement, under contract with D. MacDonald.

Many other gypsum occurrences are known in the central and northern mainland of Nova Scotia and on Cape Breton Island.

Gypsum is mined at Flat Bay Station, Newfoundland, 60 miles southwest of Corner Brook, by Flintkote Holdings Limited, mostly for export to company plants in the United States. Raw gypsum is supplied to the Corner Brook plant of Atlantic Gypsum Limited for the manufacture of gypsum wallboard products and plaster of paris, and to the cement plant operated by North Star Cement Limited, also at Corner Brook. Exports are made through the port of St. George's from an open stockpile supplied by an aerial cable tramway carrying rock from Flat Bay, six miles from the shipping site. Other gypsum occurrences are known in the southwestern lowlands, west of the Long Range Mountains.

In New Brunswick, two companies quarry gypsum. Canadian Gypsum Company, Limited, a subsidiary of United States Gypsum Company, produces gypsum for use in the manufacture of plaster and wallboard in the company-owned plant at Hillsborough. Canada Cement Lafarge Ltd. obtains gypsum from the Havelock area, west of Moncton, for use in the manufacture of portland cement at Havelock.

Other gypsum occurrences have been recorded in the southeastern counties of New Brunswick. On the Magdalen Islands in Quebec many gypsum outcrops occur.

Ontario. Two underground gypsum mines are operated in southwestern Ontario to produce raw material for three gypsum products plants and a number of cement manufacturing plants. Domtar Construction Materials Ltd. mines gypsum at Caledonia, near Hamilton, from an 8-foot seam 75 feet below the surface. Crude gypsum is shipped to other consumers as well as being supplied to the company's wallboard plant at the mine site, where a full range of gypsum building products is manufactured.

At Hagersville, southwest of Caledonia, Canadian Gypsum Company, Limited, a subsidiary of United States Gypsum Company, Chicago, produces crude gypsum by room-and-pillar mining methods from a 4-foot seam, reached through a 95-foot vertical shaft. Gypsum rock is shipped in crude form and also used by the company for the manufacture of wallboard and plaster in a plant adjacent to the mine shaft.

Gypsum has been proven at depths to 200 feet in other parts of southwestern Ontario and under 10 to 30 feet of overburden in the Moose River area south of James Bay.

Western provinces. Crude gypsum was produced in 1975 from one underground mine and one surface operation in Manitoba, and from one surface operation in British Columbia. Gypsum products plants, situated in areas exhibiting major urban growth, are supplied from Canadian producers of gypsum rock. Imports, mostly from Mexico, supply a number of cement producers.

Domtar Construction Materials Ltd. obtains crude gypsum from its quarry at Gypsumville, 150 miles northwest of Winnipeg, Manitoba, to supply its gypsum products plant at Winnipeg.

Westroc Industries Limited mines gypsum from a deposit 140 feet beneath the surface near Silver Plains, 30 miles south of Winnipeg, until mid-1975 when an inflow of artesian water from below the orebody forced closure of the mine. Crushed and screened gypsum had been supplied to company-operated gypsum products plants in Winnipeg and Saskatoon and to cement manufacturers in Winnipeg, Regina and Saskatoon. This demand is now met with crude gypsum from Gypsumville and from Windermere, B.C.

Western Gypsum Ltd., a subsidiary of Westroc Industries Limited, operates an open-pit mine near

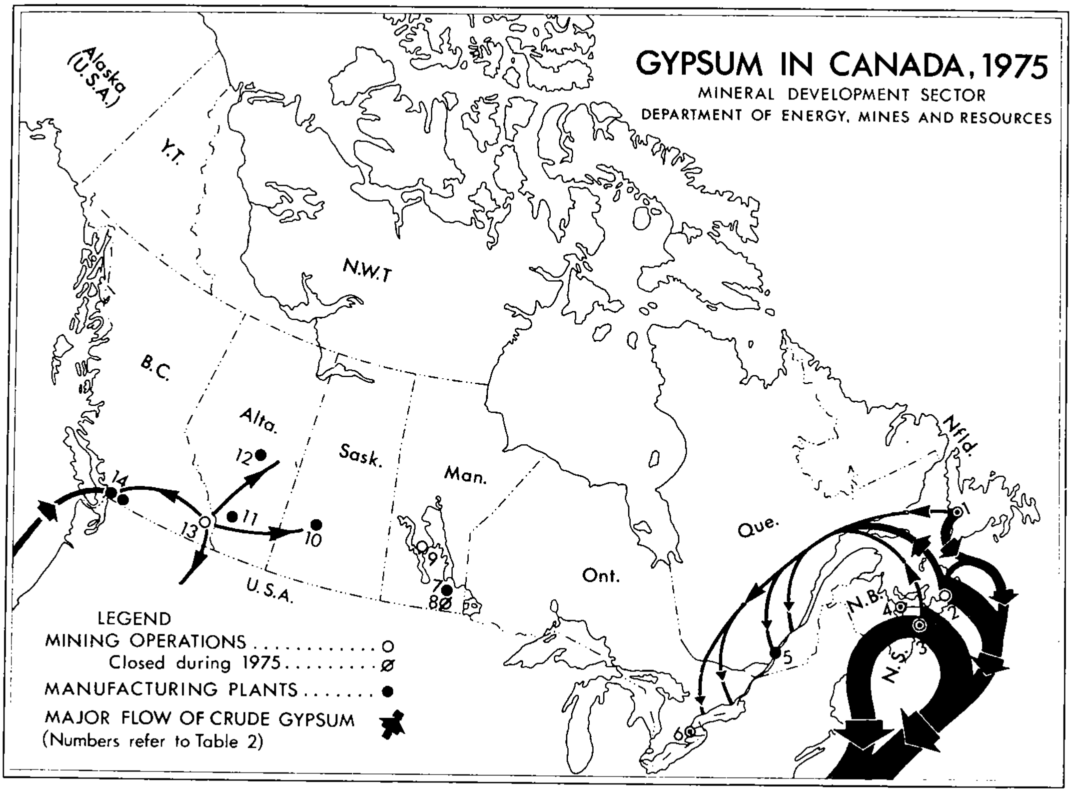


Table 2. Canada, summary of gypsum and gypsum products operation, 1975

Company	Location	Remarks
	(numbers refer to numbers on map)	
Newfoundland		
1. Flintkote Holdings Limited	Flat Bay	Open-pit mining of gypsum
Atlantic Gypsum Limited	Corner Brook	Gypsum products manufacture
Nova Scotia		
2. Little Narrows Gypsum Company Limited	Little Narrows	Open-pit mining of gypsum and anhydrite
Georgia-Pacific Corporation Bestwall Gypsum Division	River Denys	Open-pit mining of gypsum
3. Fundy Gypsum Company Limited	Wentworth and Miller Creek	Open-pit mining of gypsum and anhydrite
National Gypsum (Canada) Ltd.	Milford	Open-pit mining of gypsum
Domtar Construction Materials Ltd.	MacKay Settlement Windsor	Open-pit mining of gypsum Gypsum plaster manufacture

Table 2. Canada, (cont'd)

Company	Location	Remarks
	(numbers refer to numbers on map)	
New Brunswick		
4. Canadian Gypsum Company, Limited	Hillsborough	Open-pit mining of gypsum and gypsum products manufacture
Canada Cement Lafarge Ltd.	Havelock	Open-pit mining of gypsum used in cement manufacture
Quebec		
5. Canadian Gypsum Company, Limited	Montreal	Gypsum products manufacture
Canadian Gypsum Company, Limited	St-Jérôme	Gypsum products manufacture
Domtar Construction Materials Ltd.	Montreal	Gypsum products manufacture
Westroc Industries Limited	Ste-Cathérine d'Alexandrie	Gypsum products manufacture
Ontario		
6. Canadian Gypsum Company, Limited	Hagersville	Underground mining of gypsum and gypsum products manufacture
Domtar Construction Materials Ltd.	Caledonia	Underground mining of gypsum and gypsum products manufacture
Westroc Industries Limited	Clarkson	Gypsum products manufacture
Manitoba		
7. Domtar Construction Materials Ltd.	Winnipeg	Gypsum products manufacture
Westroc Industries Limited	Winnipeg	Gypsum products manufacture
8. Westroc Industries Limited	Silver Plains	Underground mining of gypsum Water problems forced closure of mine in mid 1975
9. Domtar Construction Materials Ltd.	Gypsumville	Open-pit mining of gypsum
Saskatchewan		
10. BACM Industries Limited	Saskatoon	Gypsum products manufacture
Alberta		
11. Domtar Construction Materials Ltd.	Calgary	Gypsum products manufacture
Westroc Industries Limited	Calgary	Gypsum products manufacture
12. BACM Industries Limited	Edmonton	Gypsum products manufacture

Table 2. Canada, (concl'd)

Company	Location	Remarks
	(numbers refer to numbers on map)	
British Columbia		
13. Western Gypsum Ltd.	Windermere	Open-pit mining of gypsum
14. Westroc Industries Limited	Vancouver	Gypsum products manufacture
Domtar Construction Materials Ltd.	Vancouver	Gypsum products manufacture
BACM Industries Limited	Vancouver	Gypsum products manufacture

Windermere in the southeastern part of British Columbia, supplying raw gypsum to its products plants at Calgary and Vancouver, to the Calgary and Vancouver plants of Domtar Construction Materials Ltd., to the Edmonton plant of BACM 'Industries Limited, to cement manufacturers in the Vancouver area, Kamloops, B.C.; Exshaw and Edmonton, Alberta, and to markets formerly supplied from the company's mine at Silver Plains, Manitoba.

Crude gypsum from Windermere has been exported to cement manufacturers in the northwestern United States.

Gypsum occurs in Wood Buffalo National Park, in Jasper National Park, along the Peace River between Peace Point and Little Rapids, and north of Fort Fitzgerald in Alberta; on Featherstonhaugh Creek, near Mayook; Canal Flats, Loos, and Falkland in British Columbia; on the shores of Great Slave Lake, the Mackenzie, Great Bear and Slave rivers in the Northwest Territories; and on several Arctic islands.

Markets, trade and outlook

Because gypsum is a relatively low-cost, high-bulk mineral commodity it is generally produced from deposits situated as conveniently as possible to areas in which markets for gypsum products exist. Exceptions occur if deposits of unusually high quality are available, even at a somewhat greater distance from markets, or if comparatively easy and inexpensive mining methods are applicable, or if low-cost, high-bulk shipping facilities are accessible. Nova Scotia and Newfoundland deposits meet all three of these criteria and have been operated by and for United States-based companies in preference to United States deposits.

Exports of crude gypsum are mainly to the eastern United States where the demand for gypsum products is closely related to activity in the construction industry. During the recent period of economic recession, the construction industry in both the United States and Canada was depressed. Although the Canadian industry rallied in early-to mid-1975, the United States industry remained depressed until near the end of the year, at which time an upturn was evident. Reduced construction activity resulted in reduced demand for

Table 3. World production of gypsum, 1974-75

	1974	1975^e
	(thousand short tons)	
United States	11,999	9,760
Canada	7,964	6,255
France	6,856	6,200
Spain	4,850	4,400
Zambia	4,157	3,700
Other Free World	24,116	22,800
Communist countries (except Yugoslavia)	8,097	7,700
World Total	68,039	60,815

Source: United States Bureau of Mines Commodity Data Summaries, January 1976 and for Canada, Statistics Canada.
^{e} Estimated.

Table 4. Canada, gypsum production, trade and consumption, 1966-75

	Production[1]	Imports[2]	Exports[2]	Apparent Consumption[3]
	(short tons)			
1966	5,976,164	85,913	4,672,518	1,389,559
1967	5,175,384	69,112	3,896,134	1,348,362
1968	5,926,940	69,062	4,463,605	1,532,397
1969	6,373,648	81,799	4,871,184	1,584,263
1970	6,318,523	38,880	4,853,304	1,504,099
1971	6,702,100	105,783	5,034,974	1,772,909
1972	8,099,480	62,390^r	5,962,973	2,198,897^r
1973	8,389,172	92,291	6,342,808	2,138,655
1974	7,964,423	62,006	5,745,720	2,280,709
1975^p	6,255,000	61,000	4,069,376	2,246,624

Source: Statistics Canada.
[1]Producers' shipments, crude gypsum. [2]Includes crude and ground, but not calcined. [3]Production plus imports minus exports.
^{p} Preliminary; ^{r} Revised.

Table 5. Canada, production of gypsum products, 1974-75

Item	1974	1975
	(square feet)	
Wallboard	1,296,843,189[r]	1,349,704,710
Lath	95,382,330	77,362,047
Sheathing	40,158,164	46,859,633
	(short tons)	
Plaster	105,483	89,000

Source: Statistics Canada
[r] Revised.

gypsum products, which in turn resulted in gypsum exports from eastern Canada being less than at any time since 1967.

Crude gypsum, mainly from the Newfoundland port of St. George's and from Halifax and Little Narrows is Nova Scotia, is shipped to the Montreal and Toronto regions for use in gypsum products manufacture and in portland cement production. Since the closure of the Westroc Industries Limited mine at Silver Plains, Manitoba, gypsum from Windermere, B.C. is rail-hauled abnormally long distances to supply the needs of cement producers and the gypsum products industry in the prairie provinces. Raw gypsum is imported on the west coast from Mexico, mainly for cement manufacture. Minor amounts of crude gypsum have been shipped to the mid-United States for agricultural use, and larger quantities exported to the northwestern United States from British Columbia, mainly for use by cement manufacturers.

Gypsum products are not shipped great distances because freight and handling costs represent a major part of the price to the consumer for items that are relatively low-priced and readily available at many locations. Although gypsum products are usually manufactured close to the consumer, with modern containerized shipments becoming more popular and with the trend to trade off economic and environmental factors, the establishment of wallboard plants at the raw material source could become attractive.

Construction expenditures in both Canada and the United States are expected to increase. Construction of homes, apartments, schools and offices will continue at a fairly high rate and the need for gypsum-based building products will rise steadily. Although new construction materials are being introduced, gypsum wallboard will remain popular because of low price, ease of installation and its well-recognized insulating and fire-retarding properties. The present structure of the gypsum industry in Canada is unlikely to change greatly in the near future. Building materials plants have sufficient capacities to meet the short-term, regional demand for products and the ability to adapt to new building techniques.

Canadian Standards Association standards A 82.20 and A 82.35 relate to gypsum and gypsum products.

World review

Gypsum occurs in abundance throughout the world but, because its use is dependent on the building construction industry, developments are generally limited to the industrialized countries. Reserves are extremely large and are conservatively estimated to be as great as 2 billion tons. Accumulations of byproduct phosphogypsum will undoubtedly become attractive as sources of calcium sulphate for both cement and wallboard manufacture in North America, as indeed they have in Europe and Japan. Increasing disposal costs will motivate the use of phosphogypsum. Stringent regulations regarding the removal of SO_2 from stack gases are not too far in the future. One of the possible products of such emission controls, if the world sulphur system does not require either sulphuric acid or elemental sulphur, would be calcium sulphate. Byproduct gypsum from this source is now being utilized in Japan. Production of sulphuric acid and coproduct cement from gypsum and anhydrite has been practised in European countries for a number of years.

The United States is the world's largest single producer and, together with Canada, brings North American production to over 30 per cent of world output. European production is about 46 per cent of the world total, France being the largest producer. Asian producers account for about 9 per cent of the world total, the four major ones being Iran, India, the People's Republic of China and Japan. Central America, South America, Africa and Oceania each produce significant amounts, with Mexico contributing by far the greatest tonnage of any country in this group.

Anhydrite

Production and trade statistics for anhydrite are included with gypsum statistics. Anhydrite is produced by Fundy Gypsum Company Limited at Wentworth, Nova Scotia, and by Little Narrows Gypsum Company Limited at Little Narrows, Nova Scotia. According to the *Nova Scotia Annual Report on Mines*, production of anhydrite in 1975 was 219,295 tons. Most of this was shipped to the United States for use in portland cement manufacture and as a peanut crop fertilizer. Cement plants in Quebec and Ontario also used some Nova Scotia anhydrite.

Table 6. Canada, house construction, by province

	Starts			Completions			Under Construction		
	1974	1975	% Diff.	1974	1975	% Diff.	1974	1975	% Diff.
Newfoundland	4,911	5,342	+ 9	4,446	4,831	+ 9	4,173	5,107	+22
Prince Edward Island	1,334	847	−37	1,664	1,130	−32	860	314	−63
Nova Scotia	6,008	6,366	+ 6	6,604	6,249	− 5	6,349	7,301	+15
New Brunswick	5,861	6,983	+19	6,812	5,804	−15	3,550	4,463	+26
Total (Atlantic Provinces)	18,114	19,538	+ 8	19,526	18,014	− 8	14,932	17,185	+15
Quebec	51,642	54,741	+ 6	58,596	51,540	−12	31,487	31,805	+ 1
Ontario	85,503	79,968	− 6	104,360	81,865	−22	78,517	75,690	− 4
Manitoba	8,752	7,845	−10	12,164	8,760	−28	5,668	4,917	−13
Saskatchewan	7,684	10,505	+37	6,487	7,705	+19	5,001	7,728	−55
Alberta	19,008	24,707	+30	21,570	17,550	−19	9,940	16,909	+70
Total (Prairie Provinces)	35,444	43,057	+21	40,221	34,015	−15	20,609	29,554	+43
British Columbia	31,420	34,152	+ 9	34,540	31,530	− 9	22,861	22,365	− 2
Total Canada	222,123	231,456	+ 4	257,243	216,964	−16	168,406	176,599	+ 5

Source: Statistics Canada.

Tariffs

Canada

Item No.		British Preferential Tariff	Most Favoured Nation	General	General Preferential
29200-1	Gypsum, crude	free	free	free	free
29300-1	Plaster of paris, or gypsum calcined, and prepared wall plaster, the weight of the package to be included in the weight for duty per 100 pounds	free	6¢	12½¢	free
29400-1	Gypsum, ground not calcined	free	free	15%	free
28410-1	Gypsum tile	15%	15%	25%	10%

United States

512.21	Gyspum, crude	free
		On and after Jan. 1, 1972
512.24	Gypsum, ground calcined	59¢ per long ton
245.70	Gypsum or plastic building boards and lath	6%

Sources: For Canada, the Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa. For United States, Tariff Schedules of the United States Annotated (1976), T.C. Publication 749.

Indium

J.J. HOGAN

Indium occurs as a minor constituent of certain ores of zinc, lead, tin, tungsten and iron. It is commonly associated with sphalerite, the most abundant zinc mineral. Indium becomes concentrated in zinc residues and smelter slags derived from zinc and lead smelting operations. It is recovered at only a few of the world's zinc and lead smelters.

Canadian output of indium in 1975 was 224,000 ounces* compared with 259,000 ounces in 1974. Cominco Ltd. is the only Canadian producer of indium and is one of the world's largest producers of the metal.

Other major producers are the United States, Japan, West Germany, Australia, Peru and Belgium. Statistical data on output and consumption of indium in these countries are not generally available, although the U.S. Bureau of Mines estimates 1975 world production at 1,500,000 ounces, with production from some individual countries varying between 100,000 and 200,000 ounces each.

The United States does not publish any data on the production or consumption of indium metal in that country. However, two companies; ASARCO Incorporated and The Indium Corporation of America, produce indium. *Metals Week* reported that ASARCO stopped producing indium at its Denver, Colorado operations at the end of July 1975 and did not expect to resume production until the second quarter of 1976. The company was servicing its customers through inventories.

Production

Indium was first recovered at Trail, British Columbia in 1941, though the presence of indium in the lead-zinc-silver ores of Cominco's Sullivan mine at Kimberley, British Columbia, had been known for many years. In 1942, 437 ounces were produced by laboratory methods. After a decade of intensive research and development, production began in 1952 on a commercial scale. At present, the potential annual production at Trail is one million ounces (about 35 short tons).

Indium enters the Trail metallurgical plants in the zinc concentrates. In the electrolytic zinc process, indium remains in the zinc calcine during roasting and in the insoluble residue during leaching. The residue is then delivered to the lead smelter for recovery of contained lead and residual zinc. In the lead blast furnaces, the indium enters lead bullion and blast furnace slag in about equal proportions. From the slag, it is recovered along with zinc and lead during slag-fuming. The fume is leached for recovery of zinc, and indium again remains in the residue, which is re-treated in the lead smelter. From the lead bullion, indium is removed in bullion dross. The dross is re-treated for recovery of copper matte and lead and, in this process, a slag is recovered which contains lead and tin, together with 2.5 to 3.0 per cent indium.

The dross re-treatment slag is reduced electrothermally to produce a bullion containing lead, tin, indium and antimony, which is treated electrolytically to yield a high (20 to 25 per cent) indium anode slime. The anode slime is then treated chemically to give a crude (99 per cent) indium metal, which is refined electrolytically to produce a standard grade (99.97 per cent) or a high-purity grade (approximately 99.999 to 99.9999 per cent) indium. The metal is cast in ingots varying in size from 10 ounces to 10 kilograms. Also produced are various alloys and chemical compounds of indium, such as indium antimonide, and a variety of fabricated forms such as discs, wire, ribbon, foil and sheet, powder, and spherical pellets.

Properties and uses

Indium is a silver-white metal that resembles tin in its physical and chemical properties. Its chief characteristics are extreme softness, low melting point and high boiling point. The metal has a melting point of 156°C; boiling point of 2,000°C; and atomic weight of 114.8. Its specific gravity at 20°C is 7.31, which is about the same as that of iron.

Indium forms alloys with precious metals and many of the base metals, improving their performance in certain special applications. Its first major use, and still an important outlet, was in high-speed, silver-lead

* The term "ounce" refers to the troy ounce throughout unless otherwise stated.

bearings in which the addition of indium increases the strength and corrosion resistance of the surfaces of the bearings. Bearings of this type are used in aircraft piston engines, diesel engines and several types of automobile engines. The standard grade of indium is used in this application.

Indium is used in low-melting-point alloys containing bismuth, lead, tin and cadmium; e.g., a bismuth-tin-cadmium-lead-indium alloy containing 19.1 per cent indium, used as a heat fuse, melts at 47°C. Indium is used in glass-sealing alloys containing about equal amounts of tin and indium; in certain solder alloys in which resistance to alkaline corrosion is required; and in gold dental alloys.

Indium is one of several metals that find application in various semiconductor devices. In these, high-purity indium, alloyed in the form of discs or spheres into each side of a germanium wafer, modifies the properties of the germanium. Indium is especially suitable for this purpose because it alloys readily with germanium at low temperatures and, being a soft metal, does not cause strains on contracting after alloying.

Discovered in 1863, but in commercial use only since 1927 when it was first used as a non-tarnish coating on silverware, indium and its compounds are relatively new materials whose potential applications are still being explored. Uses have been found in electrical contacts, resistors, thermistors, photoconductors, small lightweight batteries, and infrared detectors. Indium can be used as an indicator in atomic reactors because artificial radioactivity is easily induced in indium by neutrons of low energy (about 1.5 electron-volt). Indium foil was used as a neutron indicator in the uranium-graphite piles of the first atomic bomb project. Silver-cadmium-indium alloys are now used for reactor control rods. Indium compounds added to lubricants have a beneficial anticorrosive effect. Indium also has possible applications in decorative plating of jewellery and tableware.

The U.S. Bureau of Mines has reported a lessening in the demand for indium. It also estimated that in 1975 the uses of the metal were distributed as follows: solder, alloys and coatings, 30 per cent; instruments, 30 per cent; electronic components, 18 per cent; nuclear reactor controls, 6 per cent and other uses 16 per cent.

Foreign trade

Detailed statistics on foreign trade are not available for indium. United States imports of the metal in 1975 were estimated by the U.S. Bureau of Mines at 125,000 ounces, compared with 543,000 ounces in 1974 and 811,000 ounces in 1973. The sources of the imports for the period 1971-74 were: Canada, 39 per cent; U.S.S.R., 15 per cent; Peru, 13 per cent; United Kingdom, 11 per cent; and others, 22 per cent.

Prices

The price of indium as quoted by *Metals Week* was $5.50 an ounce from the beginning of 1975 until September 4, 1975 when the price was increased to $6.00 and it remained at this level for the balance of the year. Cominco advanced its world price for indium to $6.00 an ounce, effective January 29, 1975.

Tariffs

Canada — not specifically enumerated in Canadian tariffs.

United States

Item No.	Rate of Duty January 1, 1976
	%
628.45 Metal, unwrought, waste and scrap[1]	5
628.50 Metal, wrought	9

Source: Tariff Schedules of the United States Annotated (1976) T.C. Publication 749.
[1]Duty on waste and scrap suspended until June 30, 1978.

Iron Ore

ROGER J. GOODMAN

A year of unfulfilled promise is the most apt description of the Canadian iron ore industry in 1975. Iron ore shipments of 44.6 million tons* fell well below expectations due to labour strikes, declining demand, delays in project implementation and failure of some recently-expanded projects to attain rated production capacity. Canadian exports of iron ore also declined in 1975, in marked contrast to imports, which almost doubled from the preceding year. Shipments to domestic steel producers declined, and the rate of growth in domestic shipments will not match the growth in domestic steelmaking capacity in the medium term, requiring many Canadian steelmakers to increase their dependence upon imported ores from the United States. The reasons most commonly cited for this exodus of the Ontario-based integrated steelmakers to United States iron ore projects are high labour costs and high labour turnover at Canadian iron ore mines, changing taxation regulations in Canada, and lower capital costs in the United States, mainly due to the requirement of only minor infrastructure development. The trend to increasing dependence upon imported ore by many major Canadian steel companies will continue until a more economic operating climate is restored in Canada.

National significance of iron ore industry

Canadian iron ore production (shipments) in 1975 was 44.6 million tons, of which 35.5 million tons was exported. Iron ore production (shipments) was valued at $923 million, which ranked it fifth in value terms in the Canadian mineral industry (including mineral fuels). This represented about 7 per cent of the value of aggregate mineral production, which attained $13.4 billion in 1975. Iron ore exports were valued at $686 million and as such ranked third in value terms among Canadian mineral exports, being surpassed by only crude petroleum and natural gas. Exports comprised 9.3 per cent of overall mineral exports in value, and as minerals account for about one-third of total Canadian exports it is apparent that iron ore makes a very positive contribution to the maintenance of a favourable foreign trade balance. The importance of iron ore shipments on Canada's overall trade balance will become more significant in the medium term, given the implications of a swelling trade deficit for crude petroleum.

Iron ore production as a percentage of Gross National Product rose from 0.5 per cent in 1974 to about 0.6 per cent in 1975. In terms of value added, the iron ore industry contributed an estimated $550 million or 0.36 per cent of the Gross National Product. Capital expenditures in 1975 were an estimated $215.3 million, or 8.6 per cent of total capital expenditures of $2.5 billion disbursed by the entire Canadian mineral industry. Estimated repair expenditures of $181.3 million comprised 21.6 per cent of total repair expenditures of $840.2 million incurred by the entire Canadian mineral industry. Direct employment in the iron ore industry amounted to 15,000 people. The agglomeration stage of iron ore processing is energy intensive and in 1975 this resulted in the consumption of 108 million gallons of fuel oil in the production of 19.2 million tons of agglomerates, and 8.5 million mcf of natural gas in the production of an additional 6.2 million tons of agglomerates. During the pelletizing of 23.7 million tons of pellets in 1975, 228,551 tons of bentonite was used in the balling process for the production of green pellets.

General characteristics of the industry

The modern Canadian iron ore industry dates from the early 1950s, with the development of the large, high-grade iron ore deposits at Schefferville, Quebec. The industry is characterized by a vertically integrated market structure of producing iron ore mines and parent steel companies, and is primarily an export-oriented industry. Mines in Canada are largely owned by United States steel companies and merchant ore companies and to a lesser extent by Canadian and European steel companies. Thus, by 1977, 70.5 per cent of total installed production capacity will be controlled

* The gross or long ton (2,240 pounds) is used throughout unless otherwise specified.

by United States interests, 25.8 per cent by Canadian interests, and 3.7 per cent by European steel companies. It should be noted, however, that had it not been for the development of the iron ore industry, largely by United States interests, it is doubtful that the present degree of self-sufficiency in domestic iron ore requirements would have been attained. The Quebec-Labrador region remains the pre-eminent iron ore producing region in Canada, with a projected 82 per cent of total Canadian installed production capacity by 1977.

Canadian iron ore producers mine low- to medium-grade iron ores grading 19 to 55 per cent iron, almost all of which must be beneficiated to produce acceptable feed material for the iron and steel industry.

The increasing demand by blast furnace operators for enhanced efficiencies in pig iron production have resulted in a major increase in agglomerate production on a worldwide scale during the last decade. The development of the Canadian iron ore industry is an example, par excellence, of this trend. Direct shipping ores declined from about 68 per cent of the total iron ore produced in 1955 to 9 per cent in 1975, whereas total agglomerate production increased from about 7 per cent in 1960 to 52 per cent in 1975. Pelletizing production alone represented almost 50 per cent of total production in 1975. Concentrate production, mainly for sinter feed, has retained a reasonably consistent share of the overall market, averaging about 30 per cent of Canada's annual production over the past 15 years. This market share will increase to over 40 per cent in the medium term, however, as concentrate production from the Mount Wright project in Quebec approaches rated capacity.

Production (shipments)

The Canadian iron ore industry consists of 15 iron ore producers (including one byproduct producer), with mine operations at 17 locations across Canada. Nine operations are in Ontario, three in Quebec, two each in Newfoundland (Labrador) and British Columbia and one astride the Quebec-Newfoundland border. One of the Ontario locations is The International Nickel Company of Canada, Limited's pellet plant at Copper Cliff, where iron ore is recovered as a byproduct of nickel mining.

Table 1. Canada, iron ore production and trade, 1974-75

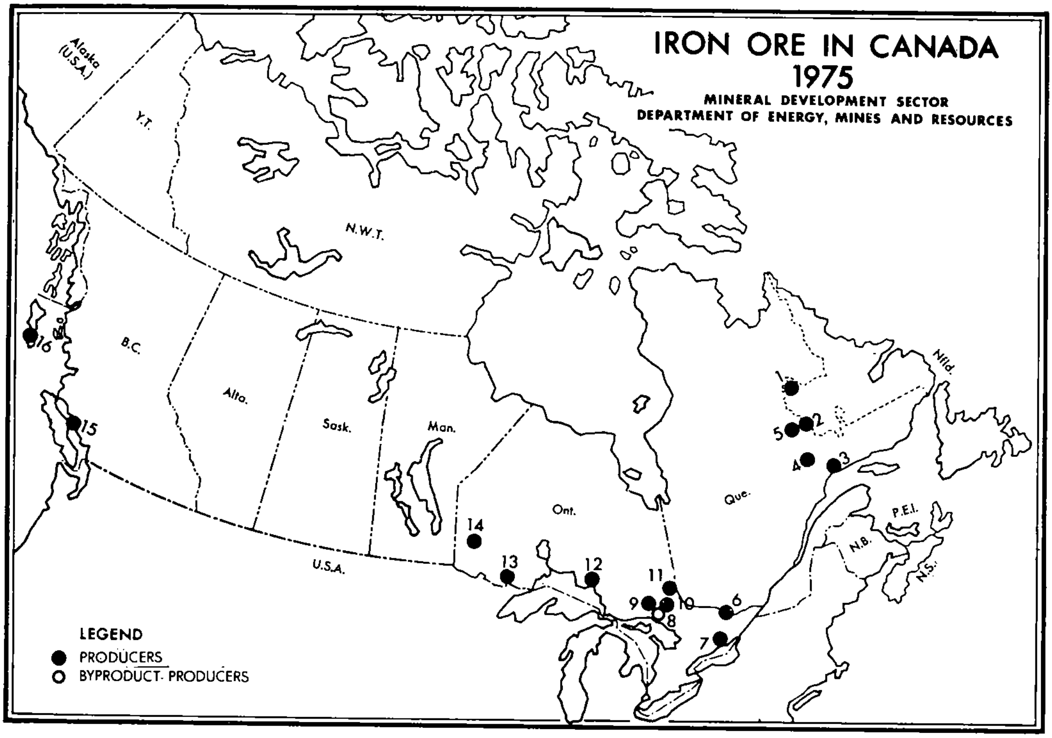
	1974		1975p	
	(long tons)[1]	($)	(long tons)[1]	($)
Production (mine shipments)				
Newfoundland	21,678,760	372,188,155	22,836,000	486,636,000
Ontario	10,733,579	180,089,730	9,164,000	214,007,000
Quebec	12,346,992	159,115,662	10,893,000	207,942,000
British Columbia	1,286,280	12,756,710	1,228,000	14,599,000
Total	46,045,611	724,150,257	44,121,000	923,184,000
By products iron ore[2]	598,000	. .	519,000	. .
Imports				
United States	1,636,550	25,854,000	3,914,979	97,600,000
Brazil	527,329	9,469,000	678,841	19,200,000
Sweden	101,300	2,253,000	125,997	4,733,000
Norway	—	—	32,593	1,038,000
Morocco	—	—	13,424	450,000
Liberia	—	—	126	3,000
South Africa	31,165	532,000	—	—
Total	2,296,344	38,108,000	4,765,960	123,024,000
Exports				
Iron ore, direct shipping				
United States	4,022,920	51,263,000	3,074,194	48,378,000
Italy	841,214	10,721,000	590,521	9,359,000
United Kingdom	902,990	8,590,000	571,613	7,270,000
Belgium and Luxembourg	415,181	5,338,000	110,021	1,717,000
Japan	185,232	2,593,000	—	—
France	139,959	1,803,000	—	—
Spain	47,210	944,000	—	—
Total	6,554,706	81,252,000	4,346,349	66,724,000

Table 1. Canada, iron ore production and trade, 1974-75 (concl'd)

	1974		1975^p	
	(long tons)	($)	(long tons)	($)
Exports (cont'd)				
Iron ore concentrates				
United States	3,299,829	44,205,000	3,684,721	65,440,000
Japan	3,907,714	31,388,000	3,924,145	41,525,000
Netherlands	1,770,842	15,631,000	2,772,230	36,614,000
United Kingdom	2,894,135	27,403,000	2,409,618	36,540,000
West Germany	1,828,171	17,767,000	1,815,970	29,487,000
Italy	566,337	5,403,000	915,156	12,801,000
France	444,474	4,114,000	472,914	6,142,000
Portugal	72,623	738,000	69,308	1,845,000
Spain	190,153	2,036,000	93,587	1,653,000
Finland	91,137	970,000	62,521	1,100,000
Australia	19,563	276,000	30,649	569,000
Bahamas	11,200	145,000	7,650	136,000
Belgium and Luxembourg	57,031	615,000	—	—
Austria	23,542	250,000	—	—
Total	15,176,751	150,941,000	16,258,469	233,852,000
Iron ore agglomerated				
United States	11,687,669	238,503,000	11,772,145	304,082,000
Netherlands	597,382	12,493,000	920,789	24,760,000
Italy	670,456	13,371,000	615,439	15,825,000
Spain	387,150	8,189,000	546,588	14,823,000
West Germany	255,966	5,197,000	273,919	7,349,000
Japan	80,429	1,794,000	222,860	5,841,000
United Kingdom	958,760	19,648,000	51,351	1,213,000
Total	14,637,812	299,195,000	14,403,091	373,893,000
Iron ore not elsewhere specified				
United States	487,168	11,164,000	456,834	11,257,000
Total exports all classes				
United States	19,497,586	345,135,000	18,987,894	429,157,000
Netherlands	2,368,224	28,124,000	3,693,019	61,374,000
Japan	4,173,375	35,775,000	4,147,005	47,366,000
United Kingdom	4,755,885	55,641,000	3,032,582	45,023,000
Italy	2,078,007	29,495,000	2,121,116	37,985,000
West Germany	2,084,137	22,964,000	2,089,889	36,836,000
Spain	624,513	11,169,000	640,175	16,476,000
France	584,433	5,917,000	472,914	6,142,000
Portugal	72,623	738,000	69,308	1,845,000
Belgium and Luxembourg	472,212	5,953,000	110,021	1,717,000
Finland	91,137	970,000	62,521	1,100,000
Australia	19,563	276,000	30,649	569,000
Bahamas	11,200	145,000	7,650	136,000
Austria	23,542	250,000	—	—
Total	36,856,437	542,552,000	35,464,743	685,726,000

Source: Statistics Canada.
[1]Dry long tons for production (shipments) by province; wet long tons for imports and exports. [2]Total shipments of byproduct iron ore compiled by Mineral Development Sector, Department of Energy, Mines and Resources, Ottawa, from data supplied by companies. Total iron ore shipments include shipments of byproduct iron ore.
^p Preliminary; — Nil; . . Not available.

Crude ore production in Canada declined in 1975 to 103 million tons compared with 109 million tons the preceding year. Shipments of final iron ore products declined to 44.6 million tons compared with 46.6 million tons in 1974. Export shipments were 35.5 million tons, a decrease of over one million tons when compared with 36.9 million tons in 1974. Domestic demand remained strong for most of the year, but consumption of domestic ores fell appreciably, mainly due to the unavailability of Wabush ores, necessitating alternative supplies being procured from the United States.



PRODUCERS

(numbers refer to numbers on map)

1. Iron Ore Company of Canada, Knob Lake Division (Schefferville)
2. Iron Ore Company of Canada, Carol Division, (Labrador City)
2. Scully Mine of Wabush Mines (Wabush)
3. Iron Ore Company of Canada, Sept-Iles Division (Sept-Iles)
3. Pointe Noire Division of Wabush Mines (Pointe Noire)
4. Quebec Cartier Mining Company (Gagnon)
5. Quebec Cartier Mining Company (Mount Wright)
6. Hilton Mines Ltd. (Shawville)
7. Marmoraton Mining Company, Division of Bethlehem Chile Iron Mines Company (Marmora)
9. National Steel Corporation of Canada, Limited (Capreol)
10. Sherman Mine of Dominion Foundries and Steel, Limited (Temagami)
11. Adams Mine of Dominion Foundries and Steel, Limited (Kirkland Lake)
12. Algoma Ore Division of The Algoma Steel Corporation, Limited (Wawa)
13. Caland Ore Company Limited (Atikokan) Steep Rock Iron Mines Limited (Atikokan)
14. The Griffith Mine (Bruce Lake)
15. Texada Mines Ltd. (Texada Is.)
16. Wesfrob Mines Limited (Moresby Is.)

BYPRODUCT PRODUCERS

8. The International Nickel Company of Canada, Limited (Copper Cliff)

Newfoundland (Labrador) was the leading provincial producer in 1975 with iron ore mine shipments of 22.8 million tons, an increase of 5 per cent compared with 21.7 million tons shipped in 1974. Quebec shipments decreased by about 11 per cent to 10.9 million tons in 1975, from 12.3 million tons in 1974. Ontario shipments declined about 14 per cent from 11.3 million tons in 1974 to 9.7 million tons. Shipments from the two iron ore producers in British Columbia decreased by 5 per cent from 1.3 million tons in 1974 to 1.2 million tons in 1975.

Canadian developments

The Canadian iron ore industry was approaching the end of a large-scale expansion wave in 1975 that will increase production capacity from 46 million tons of iron ore products in 1970 to approximately 73 million tons in 1977. The expansions have centred entirely in the Quebec-Labrador region, and as a consequence this area will possess over 80 per cent of total Canadian production capacity by 1977.

The Iron Ore Company of Canada (IOC) completed a major three-year expansion program in mid-1973, which raised production capacity at its three operations — Schefferville, Carol Lake and Sept Iles — from 20 million tons in 1970 to 31 million tons. At the Carol Lake concentrating-pelletizing complex near Labrador City, the pelletizing plant was reconstructed and a 12 million ton-a-year concentrator expansion was undertaken to increase concentrate production to about 21 million tons a year. The concentrator currently ranks as one of the world's largest iron ore beneficiation plants. Production at the pellet plant attained rated capacity in mid-1975 and was maintained until the end of 1975, following a major maintenance program embarked upon early in the year. The concentrator is expected to approach rated capacity in 1976. The Sept Iles pelletizing plant was completed in 1973, but attainment of rated capacity has been hampered severely by mechanical difficulties, shortages of key replacement components and unexpected problems experienced with the metallurgically complex feed of "treat-ore" from Schefferville. In 1975, the Sept Iles plant attained only 50 per cent of its rated capacity, even after more than two years of operation. Further improvement in the operating performance of the Sept Iles plant is expected in 1976, with attainment of a production level of about 70 per cent of its rated annual capacity. The large improvements in operating performance in 1975 did result in a substantial improvement in IOC's financial position, with a 1974 loss of $48 million being reduced to $696,000 in 1975.

After a troubled development history the mammoth Mount Wright project of Quebec Carter Mining Company (QCM) commenced tune-up operations in late 1975, almost two years after its scheduled start-up date. Meanwhile the cost of the Mount Wright project has approximately doubled from its original estimate of $380 million, due to labour strife and inflation. The project was subjected to severe construction labour unrest in 1973 and 1974, reflecting the then-prevalent trend throughout the province of Quebec. As a result in June 1974 the site was temporarily closed down by QCM, pending a satisfactory resolution of the labour turmoil. The company ultimately negotiated a new labour relations policy. Since then construction at the site has proceeded smoothly and with a marked increase in labour productivity.

The Mount Wright specular hematite deposits are located some 70 miles northeast of Gagnon, Quebec. The mine contains several billion tons of ore, grading 31.4 per cent iron and will be mined initially at a rate of about 40 million tons of crude ore annually. Included in the Mount Wright development is the construction of a concentrator and related facilities with a minimum production capacity of 18.4 million tons of iron ore concentrate (66% Fe), with provision for an ultimate annual capacity of 24 million tons of concentrate, probably in the early 1980s. Also included in the Mount Wright project was an 88 mile railway extension from Gagnon, Quebec and the construction of the innovative model town of Fermont.

Production at Mount Wright in 1975 was 406,000 tons, none of which was shipped to consumers. The Mount Wright operation is expected to produce some 6 to 8 million tons of concentrate in 1976, and approach its full rated capacity in 1977.

(text continued on page 241)

Table 2. Canada, iron ore producers, 1974 and 1975

Company and Property Location	Participating Companies	Material Mined &/or Treated 1975	Product Shipped 1975	Shipments 1974	Shipments 1975
		(% Fe natural)	(% Fe dry/wet)	(000 wet long tons)	
Adams Mine: Boston Twp., near Kirkland Lake, Ont.	Dominion Foundries and Steel, Ltd.; managed by Cliffs of Canada Limited, a wholly-owned subsidiary of The Cleveland-Cliffs Iron Company	Magnetite from open-pit mine (21)	Pellets (65/65)	1,142	1,135
Algoma Ore Division of The Algoma Steel Corp. Ltd.; mines and sinter plant near Wawa, Ont.	Wholly owned	Siderite from open-pit and underground mine (33)	Siderite sinter (48/48)	2,077	1,494[1]
Caland Ore Co., Ltd.; east arm of Steep Rock Lake, near Atikokan, Ont.	Inland Steel Company	Hematite and goethite from open-pit mine (54)	Pellets (63/63) Concentrate (58/55) Direct Shipping[2] (58/54)	1,034 930 —	690 805 —
Griffith Mine, The; Bruce Lake, 35 miles south of Red Lake, Ont.	The Steel Co. of Canada, Ltd.; managed by Pickands Mather & Co.	Magnetite from open-pit mine (23)	Pellets (67/67) (Sponge Iron)	1,569 —	1,448[3] 15
Hilton Mines, Ltd.; near Shawville, Que., 40 miles NW of Ottawa	The Steel Co. of Canada, Ltd., 50%; Jones & Laughlin Steel Corp., 25%; Pickands Mather & Co. (managing agent), 25%	Magnetite from open-pit mine (21)	Pellets (66/66)	930	773
Iron Ore Company of Canada 1. Schefferville Quebec-Labrador operation	Labrador Mining and Exploration Co. Ltd., 3.84 Hollinger Mines Ltd., 8.27 The Hanna Mining Co. (managing agent), 27.24	Hematite-goethite-limonite from open-pit mines (54)	Direct-shipping ore (59/54) Treat Ore (54/50)	6,568	4,069
2. Carol Lake, Labrador operation	Bethlehem Steel Corp. 19.42, Armco Steel Corp. 6.06, Lykes-Youngstown Corp., 6.06	Specular hematite and magnetite from open-pit mines (39)	Pellets (64/64) Conc. (63/62)	7,572 4,443	9,017 6,360

3. Sept-Iles, Que., Pellet operation	National Steel Corp., 18.20, Republic Steel Corp., 6.06, Wheeling-Pittsburgh Steel Corp., 4.86	Hematite-goethite-limonite from open-pit mines, Schefferville area (50)	Pellets (63/61)	1,885 —	2,958 —
Marmoraton Mining Co., Division of Bethlehem Chile Iron Mine Company, near Marmora, Ont.	Bethlehem Steel Corp.	Magnetite from open-pit mine (42)	Pellets (64/64)	520	278
National Steel Corporation of Canada, Ltd. Moose Mountain Mine; Sudbury area, 20 miles north of Capreol, Ont.	National Steel Corp. (The Hanna Mining Co. is the managing agent)	Magnetite from open-pit mine (33)	Pellets (63/63)	686	662
Quebec Cartier Mining Company 1. Gagnon, Quebec 2. Mount Wright, Quebec	United States Steel Corp.	Specular hematite from open-pit mine (35) Specular hematite from open-pit mine (34)	Specular hematite conc. (66/64) Specular hematite[4] conc. (66/64)	8,450 —	8,136 —
Sherman Mine; near Temagami, Ont.	Dominion Foundries and Steel; Limited, 90% Tetapaga Mining Company (wholly-owned subsidiary of The Cleveland-Cliffs Iron Company), 10%. The operation and management of the mine is by Cliffs of Canada Limited, also a wholly-owned subsidiary of The Cleveland-Cliffs Iron Company.	Magnetite from open-pit mines (20)	Pellets (66/65)	1,029	1,099
Steep Rock Iron Mines Ltd.; Steep Rock Lake North of Atikokan, Ont.	Publicly-owned company	Hematite-goethite from open-pit mine (55)	Conc. (58/54) Pellets (63/62)	12 1,341	5 1,104
Texada Mines Ltd.; Texada Island, B.C.	Kaiser Aluminium & Chemical Corp.	Magnetite and chalcopyrite from underground mine (31)	Magnetite concentrate (64/60)	326	307

Table 2 (concl'd)

Company and Property Location	Participating Companies	Material Mined &/or Treated 1975	Product Shipped 1975	Shipments 1974	1975
		(% Fe natural)	(% Fe dry/wet)	('000 wet long tons)	
Wabush Mines; Scully Mine includes mine and concentrator at Wabush, Labrador; Pointe Noire Division includes pelletizing plant at Pointe Noire, Que.	The Steel Co. of Canada Ltd., 25.6%; Dominion Foundries and Steel, Ltd. 16.4%; Youngstown Sheet and Tube Company, 15.6%; Inland Steel Co., 10.2%; Interlake, Inc., 10.2%; Wheeling-Pittsburgh Steel Corp., 10.2%; Finsider of Italy, 6.6%; and Pickands Mather & Co., (managing agent), 5.2%.	Specular hematite and some magnetite from open-pit mine (35)	Pellets (66/64) Conc. (66/64)	5,445 18	3,207 —
Wesfrob Mines Limited; Tasu Harbour, Moresby Is., Queen Charlotte Is., B.C.	Falconbridge Nickel Mines Limited	Magnetite and chalcopyrite from open-pit mines (40)	Pellet-feed concentrate (69/63) Sinter-feed concentrate (60/58)	617 413	600 405
Byproduct Producers					
The International Nickel Co. of Canada Ltd.; Copper Cliff, Ont.	Publicly-owned company	Pyrrhotite flotation concentrate (57) treated	Pellets (66/65)	598	509
Quebec Iron and Titanium Corp.; mine at Lac Tio, Que.; electric smelter at Sorel, Que.	Kennecott Copper Corp.; Gulf & Western Industries, Inc. New Jersey Zinc Co.)	Ilmenite-hematite ore (40% Fe, 35% TiO_2)from open-pit mine at Lac Tio, beneficiated and calcined at Sorel	Ilmenite calcine electric smelted to TiO_2 slag and various grades of desulphurized pig iron ore remelt iron	500	414[5]

Sources: Company reports, personal communication.
[1]Includes 205,527 tons of regular sinter; 1,287,190 tons of superfluxed sinter; 1,244 tons of crude ore shipped as food supplement to livestock industry. [2]Excludes 243,089 tons of direct shipping ore sent to Steep Rock Iron Mines Limited. [3]Includes 36,332 tons of oxide pellets consumed in the SL-RN direct reduction kiln, to produce 16,502 short tons of sponge iron. [4]Mount Wright commenced production in late-1975, but no shipments were made in 1975. [5]Pig iron.
— Nil.

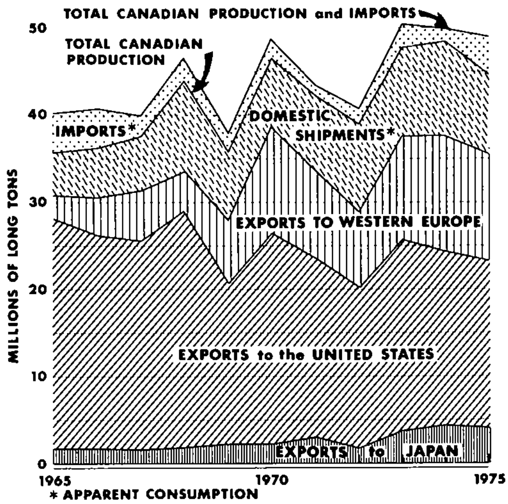
QCM is also involved in the Fire Lake development in Quebec and this project was also the scene of considerable activity in 1975, particularly in its corporate development. The project has been somewhat slow to materialize because of concern over labour problems in the province of Quebec and the withdrawal of one of the original partners in the venture — The Steel Company of Canada Limited — in 1974. To prevent further delays in the implementation of the project, the Premier of Quebec, Robert Bourassa, announced in 1975 the purchase of the Fire Lake iron ore mine, the Lac Jeannine beneficiation facilities, and the planned construction of a pellet plant by Sidbec-Dosco Limited, the provincial steel company. It was later confirmed that British Steel Corporation had also decided to take a major share in the project, and the final corporate structure will be Sidbec-Dosco Limited, 50.1 per cent, British Steel Corporation, 41.67 per cent and Quebec Cartier Mining Company, 8.23 per cent. The Fire Lake mine is situated approximately half-way between Gagnon and Mount Wright and only a few miles from the Cartier Railway line. Ore reserves at Fire Lake are estimated at about 400 million tons of specular hematite, grading 33.5 per cent iron. Crude ore from Fire Lake will be railed to the Lac Jeannine concentrator, 51 miles to the southsouthwest. Output from the Lac Jeannine concentrator will be reduced gradually from the rate of just over 8 million tons in 1975 to 6 million tons in 1977, when only Fire Lake ore will be beneficiated. The six million tons of Fire Lake concentrate from the Lac Jeannine beneficiation plant will be railed 190 miles south to Port Cartier. At Port Cartier two separate pelletizing lines are under construction, each to produce three million tons a year. Three million tons of Fire Lake concentrate will be upgraded by a secondary concentrator at Port Cartier and pelletized separately to produce a high-iron, low-gangue direct reduction feed (68 per cent iron). The remaining three million tons of cencentrate will be pelletized directly to produce a standard blast furnace pellet (65.5 per cent iron). The pellet plant is scheduled for start-up in mid-1977.

In Newfoundland in 1975 the most important event in iron ore development was the unexpected expropriation by the Newfoundland government in July that provided for the reversion to the province of certain mineral lands embracing 1.29 square miles of the Julian Lake iron ore deposit near Wabush, Labrador. The government claimed that Canadian Javelin Limited had not proceeded with due diligence to develop mining operations at the site. These allegations were vehemently denied by Canadian Javelin officials, who cited $3.4 million expenditures on the project over the past 15 years. Compensation arrangements remain to be finalized, with the Newfoundland government imposing a ceiling value of $750,000.

Meanwhile Dominion Jubilee Corporation Limited, in which Canadian Javelin holds a 33.3 per cent interest, received a preliminary feasibility study on its

CANADA IRON ORE PRODUCTION, IMPORTS, EXPORTS and DOMESTIC SHIPMENTS

MINERAL DEVELOPMENT SECTOR
DEPARTMENT OF ENERGY, MINES AND RESOURCES



Star O'Keefe iron ore deposits southwest of Mount Wright, Quebec. The report concludes that an economic project could be realized, based upon total reserves of 267 million tons of ore grading 32.9 per cent iron. The crude ore would be mined at a rate of 15 million tons a year to produce six million tons of concentrate. Capital costs were estimated at $229.6 million.

In Ontario, developments on the Lake St. Joseph iron ore deposits owned by Steep Rock Iron Mines Limited (SRIM) came to a virtual standstill in 1975. Although the development consortium remains intact, participating steel companies were preoccupied during the year with bolstering sagging steel demand, rather than initiating new, large-scale, greenfield iron ore projects. Acquisition of SRIM by Canadian Pacific Investments Limited (CPI), however, may have important ramifications on the long-term development of the Lake St. Joseph iron ore deposits. The successful takeover bid by CPI was initiated in January 1976 with an offer to purchase 4.85 million shares or about 60 per cent of SRIM's issued shares at $3 a share. The offer was accepted by a majority of shareholders in February 1976, with more than 5.4 million shares or 67 per cent of SRIM's common shares being tendered. It is of interest that in addition to control of SRIM, CPI also controls Algoma Steel Corporation, which currently purchases iron ore from SRIM's existing iron ore mines at Atikokan, Ontario. Algoma is also one of the participants in the Lake St. Joseph development consortium.

Although the CPI takeover is unlikely to stimulate the development of the Lake St. Joseph iron ore deposits in the short term, it has undoubtedly relieved any concerns over SRIM's ability to finance its share of the project, over a longer term, when the demand for iron ore from this region finally materializes.

An interesting proposal for the development of northern Ontario iron ore deposits for the domestic steel industry was put forward by Algoma Steel Corporation at the annual meeting of the American Iron Ore Association at Hamilton, Ontario, in June 1975. This involved the development of two iron ore regions in northern Ontario; one at the Lake St. Joseph area, with reserves in excess of 660 million tons of final iron ore products, and the other at the Geraldton-Nakina area, with reserves in excess of 200 million tons of final iron ore products. The crude ores would be concentrated at the mine site, prior to slurry pipeline transportation to a pelletizing complex on Lake Superior, with an eventual capacity of possibly 20 million tons of oxide pellets.

The Ontario government is also involved in studies on the sociological aspects of any developments at the Lake St. Joseph region and in 1975 two studies were commissioned. The first study related to the choosing of a site for a new community of up to 10,000 people and, the second was an environmental impact study. The Ontario government is believed to have completed a study on the provision of railway facilities to the Lake St. Joseph area.

In view of the medium-term commitments of the Ontario integrated steel companies to United States iron ore projects, and the requirement of extensive infrastructure development at Lake St. Joseph, it appears unlikely the project will materialize before at least the mid-1980s. Ideally, SRIM would like to continue mining operations at Atikokan at least until the Lake St. Joseph deposits are developed. Yet uncertainties regarding the economics of iron ore mining at Atikokan may compel it to discontinue mining in 1979. To enable iron ore mining to proceed beyond this date SRIM is currently negotiating with Caland Ore Company on its plans to vacate its mine at Atikokan. If Caland does vacate in 1979, as they have indicated tentatively, SRIM could develop this property further and prolong mining operations at Atikokan, possibly to beyond 1990.

Dominion Foundries and Steel, Limited was active in increasing its iron ore holdings in 1975 with the purchase of Anaconda Iron Ore (Ontario) Limited's property at Nakina, Ontario for $10 million. Although Dofasco has no immediate plans to develop the property, it is strategically located for development, requiring only minor infrastructure development in addition to mine and processing implementation. The two orebodies at Nakina are believed to contain estimated ore reserves of about 300 million tons of low-grade magnetite.

Table 3. Production and capacity of pig iron and crude steel at Canadian iron and steel plants, 1974-75

	1974	1975^p
	(short tons)	
Pig iron Production	10,386,306	10,086,143
Capacity at December 31	11,700,000	13,470,000
Steel ingots and castings		
Production	15,017,278	14,357,468
Capacity at December 31	18,838,500	19,136,000

Source: Statistics Canada.
^{p} Preliminary.

Canadian trade

Canadian exports of iron ore declined by 4 per cent in 1975 to 35.5 million tons, compared with 36.9 million tons in 1974. The United States remained Canada's pre-eminent market (19.0 million tons) followed by Europe (12.3 million tons), and Japan (4.2 million tons). Of total Canadian exports to the European Community, the Netherlands was the largest importer with 3.7 million tons, followed by the United Kingdom with 3.0 million tons, Italy with 2.1 million tons and West Germany with 2.1 million tons.

Canadian imports of iron ore increased dramatically in 1975 to a level of 4.8 million tons more than double the 1974 level of 2.3 million tons. The large increase in imports was largely a result of the first full year of production at the Tilden Mine in Michigan, in which Stelco and Algoma are participants, and the need by Dofasco and Stelco to purchase United States ore to replace shipment deficits caused by a strike at their partly owned Wabush Mines.

The United States accounted for 81 per cent of total Canadian iron ore imports in 1975, Brazil accounted for 14 per cent, and the remaining imports came from Sweden, Norway and Morocco. The non-United States imports were consumed at the direct-reduction — electric steel-making complex of Sidbec-Dosco Limited, Contrecoeur, and the integrated steel complex of Sydney Steel Corporation at Sydney, Nova Scotia.

Canadian consumption

In a year marked by the severest world-wide recession since the 1930s, the Canadian steel industry performed exceptionally well in 1975. Although apparent rolled steel consumption fell about 16.2 per cent compared with the preceding year, crude steel production decreased by only 4.4 per cent. Canadian consumption of iron ore thus declined to 12.5 million tons in 1974, some 0.3 million tons below the 1974 level. This excludes iron ore consumed in the Midrex direct reduction plant of Sidbec-Dosco Limited at Contrecoeur, Quebec, which amounted to about 0.53 million tons in 1975.

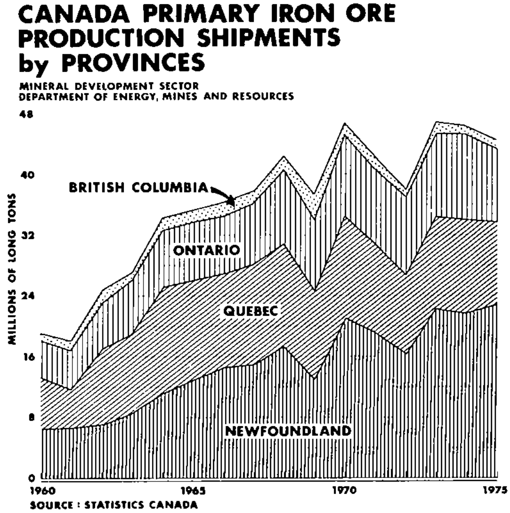
Table 4. Receipts, consumption and stocks of iron ore at Canadian iron and steel plants, 1974-75

	1974	1975p
	(long tons)	
Receipts imported	2,090,670	3,941,149[1]
Receipts from domestic source	10,376,552	9,417,786[2]
Total receipts at iron and steel plants	12,467,222	13,358,935
Consumption of iron ore	12,929,531	12,474,589[3]
Stocks of ore at iron and steel plants, December 31	3,386,881	4,260,699
Change from previous year	-495,344	+873,818

Source: American Iron Ore Association, compiled from company submissions.
[1]Compared with 4,765,960 tons in Table 1. [2]Compared with domestic shipments of 9,966,723 tons compiled by Statistics Canada. [3]Compared with 12,644,109 tons compiled by Statistics Canada for blast furnace consumption.
p Preliminary.

According to the American Iron Ore Association, of total iron ore consumption of 12.47 million tons in 1975, 9.16 million tons was of domestic origin, 3.18 million tons was from the United States and 0.13 million tons from other foreign sources. Receipts at Canadian iron and steel plants, however, attained 13.36 million tons compared with 12.47 million tons in previous year. Thus iron ore inventories at Canadian furnace yards increased from 3.39 million tons in 1974 to 4.26 million tons in 1975.

United States iron ore comprised 26 per cent of all ore consumed by Canadian steelmakers in 1975, compared with 17 per cent in 1974. This upward trend in consumption of imported United States ores will continue in the medium term, as Ontario steelmakers continue to assume equity positions in United States taconite projects. Algoma and Stelco have taken equity positions in the Tilden Mine, Michigan, which attained about 70 per cent of rated capacity during its first year of operation in 1975. In addition, Stelco has taken equity position in two taconite projects in Minnesota. Its participation in the Eveleth Taconite Co. mine in the Mesabi Range of Minnesota will provide Stelco with an additional one million tons of pellets a year commencing in late 1976. A 10 per cent interest in Hibbing Taconite Co., Minnesota will provide an additional annual supply of 0.55 million tons of pellets commencing in 1976. Dofasco is also involved in the expansion plans of Eveleth Taconite Co. and will receive 0.60 million tons of pellets annually when production commences in 1976. In addition, Algoma and Stelco are likely to participate in an expansion of the Tilden Mine in Michigan tentatively scheduled for the late 1970s.



World highlights

Angola. Companhia Mineira do Lobito's Cassinga iron ore mine was temporarily closed in the fall of 1975 due to the Angolan political conflict. The bulk of Cassinga's shipments go to the Japanese and Western European markets, and due to the iron ore oversupply situation prevailing in 1975, the disruption in shipments caused no problems for consumers. The Cassinga mine is expected to resume production in late 1976, depending on the availability of technical personnel, most of whom were Portuguese, and the condition of the railway from mine-site to port after the fighting amongst conflicting political factions.

Australia. The year was marked by plummeting demand for iron ore, with cutbacks in shipments to Japan and Europe, delays in the implementation of new projects, and an aggressive stance by Australian producers towards Japanese consumers on price levels. According to Australian producers the low prices being paid by Japanese consumers is severely constraining expansion projects at Goldsworthy's Area C ore zone, the Marandoo project of Texasgulf Inc. and Hanwright, and the Deepdale development of The Broken Hill Proprietary Company Limited. At year-end, Australian producers were requesting increases of up to 80 per cent from the Japanese steel producers, arguing that prices paid by the Japanese for iron ore products are in general about 40 per cent less than prices paid by European and American steel producers on an fob basis.

Brazil. The year marked a continuance of aggressive Brazilian government policies for increasing penetration of export iron ore markets, notably in Western Europe and Japan. Such a policy aims to establish Brazil as the world's leading exporter of iron ore by the mid-1980s, with exports of over 160 million tons. Escalating costs led to delays in the implementation of the most significant iron ore development in Brazil — the Carajas deposits in the state of Para, which reportedly contain 16 billion tons of high-grade ore. The deposits are being developed by Amazonia Mineraçao S.A., a joint venture corporation owned 51 per cent by Cia. Vale do Rio Doce (CVRD) and 49 per cent by United States Steel Corporation. The staggering cost of the project, estimated at well over $2 billion, has caused U.S. Steel to freeze its investment plans temporarily, and it is in the process of negotiating a reduced equity position, with British, Spanish, Italian and Japanese steel companies contemplating equity positions. The result of these tribulations is that a 1977 start-up date is now wholly unrealistic and start-up is unlikely to occur before the mid-1980s.

Ivory Coast. Development work continued on the Mount Klahayo project in 1975 and a decision on whether to bring the mine into production may be made in 1976. The Mount Klahayo iron ore project is a consortium venture of British, Dutch, French and Japanese steel companies in conjunction with Pickands Mather International and the government of Ivory Coast. Tentative plans call for a 12 million ton per annum iron ore mine, concentrating and pelletizing complex, and a 186-mile railway to a major Atlantic coast port.

Peru. The Peruvian government announced on July 14, 1975 the nationalization of the Marcona Mining Company. This Company, a subsidiary of Marcona Corporation, a United States multinational corporation, had operated iron ore mines in Peru since 1953. As a result of the nationalization, iron ore shipments came to a standstill in July 1975 and were not resumed until early 1976, when agreement on compensation terms between Marcona and the Peruvian government were believed to be imminent. The marketing of iron ore has been taken over by Minero Peru Commercial (Minpeco), which has to date successfully negotiated sales contracts with Rumania, Yugoslavia, and Japan.

Table 5. Canadian consumption of iron-bearing materials at iron and steel plants[1], 1975

	In Sinter Plants[2]	In Direct Reduction Plants	In Iron and Steel Furnaces: Pig Iron Furnaces	Steel Furnaces	Total in Furnaces
			(long tons)		
Iron Ore					
Crude and concentrates	230,557	—	225,626	30,429	256,055
Pellets	178,045	535,716	10,281,550	64,109	10,345,659
Sinter	75,405	—	1,379,260	—	1,379,260
Subtotal	484,007	535,716	11,886,436	94,538	11,980,974
Sinter produced at Steel plant	—	—	1,120,195[3]	—	1,120,195
Total	484,007	535,716	13,006,631	94,538	13,101,169[4]
% Fe	58.29	66.70	61.99	65.45	62.01
Other iron-bearing materials					
Flue Dust	142,807	—	—	—	—
Scale, reduced pellets, etc.	499,236	—	450,543	—	450,543
Total	642,043	—	450,543	—	450,543
% Fe	50.24	—	26.94	—	26.94

Source: Compiled by Mineral Development Sector, Department of Energy, Mines and Resources, Ottawa.
[1]All integrated producers, except Quebec Iron and Titanium Corp.; [2]Sinter plants located at steel works consume "new iron ore" "screenings" as well as other iron-bearing materials; [3]Sinter produced mainly from 484,007 tons of "new iron ore" and 636,188 tons of other iron-bearing materials; [4]Includes any sintered iron-bearing materials. Total iron ore consumption of "new iron ore" is an estimated 13.001 million tons, comprising 11.981 million tons of iron ore in furnaces, 0.536 million tons of pellets in direct reduction plants and 0.484 million tons of iron ore fines in sinter plants.
— Nil.

Sierra Leone. Due to recurring losses in recent years, the Sierra Leone Development Co. Ltd. ceased operations in October 1975 and the company was placed in voluntary receivership. The company was owned 95 per cent by a British industrial and financial group, William Baird & Co. Ltd., and had successfully mined iron ore in Sierra Leone for the past 40 years. In the 1960s the Sierra Leone Development Co. Ltd. boosted its production capacity to 3.1 million tons per year, although record production attained only 2.6 million tons in 1971. Shipments of iron ore from Sierra Leone were shipped to the Japanese and Western European markets.

South Africa. Progress continues on the large Sishen-Saldanha Bay iron ore project of the South African Iron and Steel Industrial Corporation (Iscor), which is destined to make South Africa a significant iron ore exporter by 1980. The project includes the development of a new mine at Sishen with an ultimate annual capacity of 15 million tons of iron ore, the construction of a 920 kilometre railway line to Saldanha Bay and the development of a deepwater port at Saldanha Bay. Shipments from the Sishen mine should commence in 1976 and attain 15 million tons by the early 1980s, and combined with other mines in the area will raise South Africa's iron ore shipments to over 35 million tons annually.

Table 6. World iron ore shipments, 1973-74

	1973	1974[p]
	(000 metric tons)	
U.S.S.R.	216,104	223,200
United States	89,692	83,050
Australia	85,887	96,797
Brazil	55,019	74,979
France	54,228	54,266
Canada	48,132	47,977
China	45,000	46,000
Sweden	33,307	34,469
India	34,426	33,800
Venezuela	21,946	25,952
Liberia	25,329	25,370
Eastern Europe	14,495	14,650
Mauritania	10,288	11,616
South Africa	10,955	11,553
Peru	9,582	10,549
Chile	9,463	10,455
Spain	7,466	8,998
Angola	6,205	5,276
Others	57,376	32,143
TOTAL	834,900	851,100

Sources: Mineral Development Sector, Department of Energy, Mines and Resources, Ottawa. *Metal Bulletin* and others.
[p] Preliminary

United States. In an effort to maintain iron ore self-sufficiency at about 66 per cent of total iron ore consumption, a large-scale expansion of the iron ore industry in the United States is now fully under way. The facilities are located mainly in Minnesota and include new developments of the Hibbing Taconite Co., and the Minorca mine of Inland Steel Mining Co., with large expansions of existing facilities at the Minntac operation of United States Steel Corporation, the Eveleth Expansion Co., and the National Steel Pellet Co. By 1978, when the current wave of expansion activity will be completed, the combined annual production capacity of all eight taconite operations on the Mesabi iron range will total about 65 million tons of iron ore pellets, an increase of 58 per cent from the current 41 million tons. The additional capital investment required for these large Minnesota iron ore projects will likely exceed one billion dollars. In addition, the Tilden Mine in Michigan completed its first full year of operation in 1975. A doubling of its current rated annual capacity of four million tons is slated for the late 1970s.

Venezuela. Despite the nationalization of the iron ore industry in 1974, the two original owners — the United States Steel Corporation and Bethlehem Steel Corporation — agreed to operate the mines for a one-year transition period in 1975. Effective January 1, 1976, however, mine management will be assumed by a Venezuelan government-owned company, Empresa Ferrominera Orinoco. In addition, the newly-formed Venezuelan state iron ore company is planning to build up its own shipping fleet to handle iron ore sales to Europe. Given the ambitious plans of the Venezuelan steel industry however, it is intended that most iron ore shipments will eventually be diverted from export markets to domestic steel mills.

The Association of Iron Ore Exporting Countries

The Association of Iron Ore Exporting Countries (AIEC) was formally established on April 2-3, 1975 at Geneva. By year-end the following countries had become signatories to the agreement: Algeria, Australia, Chile, India, Mauritania, Peru, Sierra Leone, Sweden, Tunisia and Venezuela. Canada declined to join the AIEC, in line with its avowed preference for joint producer-consumer forums on trade matters. Brazil declined membership on similar grounds. Without participation by such significant exporters of iron ore as Brazil, Canada and Liberia, the ability of the exporters association to influence price and supply is severely inhibited. As presently formulated, however, the Association will supposedly act solely as a consultative vehicle, and not a price-fixing cartel. One of the major objectives of the Association, however, is to assist member countries to secure fair financial returns from the exploitation, processing and marketing of iron ore with a view to improving their export earnings and terms of trade. The current members of the Association control approximately 26 per cent of world iron ore production, but almost 50 per cent of world trade. Thus, it is the significant share of iron ore marketed in world markets by AIEC members which will be critically viewed by the major importing countries of Japan, Western Europe and the United States.

World supply and demand

A major world-wide recession pervaded the market economy countries in 1975, resulting in plummeting steel consumption and production. World steel production declined by 8.2 per cent from 710 million metric tons in 1974 to 652 million metric tons in 1975. This decline in world steel production would have been far higher had not the steel industries in the planned economy countries experienced an overall growth in steel production of 6.5 per cent in 1975.

The recession was particularly severe in the United States and the European Economic Community. Steel production in the United States declined by 19.7 per cent to 106.0 million metric tons, and in the European Economic Community declined by 19.5 per cent to 125.3 million metric tons. In Japan, steel production declined 12.7 per cent to 102.2 million metric tons. Among the market economies the only major steel-producing countries to register an increase in steel production over the preceding year were Australia (1%), Brazil (12%), India (13%), Mexico (6%), and South Africa (17%). The U.S.S.R. remained the world's largest steel producer with 142 million metric tons, an increase of 4.3 per cent over the preceding year.

With a decline of about 14 per cent in non-communist world steel production in 1975, it was not surprising that an oversupply situation developed in the non-communist world iron ore industry. Production and shipments or iron ore did not decline proportionally with steel activity in all countries, however, and production and export shipments fell only slightly below 1974 levels in Australia, Brazil, Canada and Chile. This was due to a policy of inventory accumulation by consuming countries, a reluctance by consumers to declare force majeure on foreign iron ore shipments and an increased bargaining strength among exporting countries. In addition there were unforeseen disruptions of iron ore shipments in some countries such as Angola, Mauritania, Peru and Sierra Leone due to political, nationalization or other problems. The downturn in world steel activity did inflict shipment cutbacks in some iron ore exporting countries, however, notably Liberia, Sweden and Venezuela, where shipments fell appreciably below 1974 levels.

Prices and markets

The market for iron ore is governed largely by consumption in the four major world steel markets in Japan, Western Europe, Eastern Europe and the United States. These four consuming markets currently account for about 86 per cent of world iron ore consumption. Of these markets Eastern Europe is almost totally dependent on indigenous iron ore or imports from the U.S.S.R., though some Comecon countries are beginning to import minor quantities of iron ore from several noncommunist countries, Canada exports iron ore to all the major consuming centres, except the Comecon group of countries.

International iron ore prices were extremely buoyant in 1975, despite depressed demand precipitated by the worst recession in the market economies since the 1930s. Increasing fob prices for iron ore in the face of a marked downturn in demand were induced by market inflationary forces on costs, notably labour and fuel; lock-in price clauses of many short-and long-term contracts, and a new respect for the bargaining leverage

Table 7. Lake Erie base prices of selected ores, 1964-76

	1964-69	1970	1971-72	1973[1]	1973[2]	1974[3]	1975[4]	1975[5]	1976[6]
					($ U.S. per long ton)				
Mesabi Non-Bessemer	10.55	10.80	11.17	11.71	11.91	15.06	17.28	18.50	19.25
Mesabi Bessemer (+ phos. premium)	10.70	10.95	11.32	11.86	12.06	15.04	17.53	18.75	19.50
Old Range Non-Bessemer	10.80	11.05	11.42	11.96	12.16	15.14	—	—	—
Old Range Bessemer	10.95	11.20	11.57	12.11	12.31	15.29	—	—	—
High Phosphorous	10.55	10.80	10.80	—	—	—	—	—	—
Pellets (per long ton natural unit)[7]	0.252[8]	0.266	0.280	0.291	0.300[9]	0.380[10]	0.446	0.472	0.505

Source: Mineral Development Sector, Department of Energy, Mines and Resources, Ottawa.
[1]Increase effective January 1, 1973. [2]Increase effective March 1973. [3]Increase effective August 1974. [4]Increase effective January 1975. [5]Increase effective July 8, 1975. [6]Increase effective January 20, 1976 [7]Equals 1% of a ton i.e. 22.4 pounds for a long ton unit. An iron ore containing 60% Fe therefore has 60 units. [8]Price applicable for years 1962 to 1969 [9]Increases effective March 1973 and October 1973 [10]Increases effective May 1974, June 1974, August 1974 and December 1974.
— Nil.

of iron ore exporting countries. Freight rates declined substantially in 1975, due to a vast worldwide surplus of shipping, and hence cif prices of iron ore did not demonstrate as large an increase as characterized fob prices.

United States market

Total receipts of iron ore at United States steel plants in 1975 were 112.7 million tons, a decrease of 12 per cent from the preceding year's receipts of 128.3 million tons. Domestic shipments accounted for 72.4 million tons or 64 per cent of total receipts. According to the American Iron and Steel Institute, Canada was the major exporter of iron ore into the United States market with 17.7 million tons. United States iron ore imports from other sources totalled 22.6 million tons, with Brazil, Liberia and Venezuela being the prime sources of supply. The United States steel industry is likely to retain a two-thirds dependence on domestic ore supplies in the long-term, as new projects and expansions continue to be developed in the iron ranges of the Mid-West. Due to depressed demand in 1975 and a continuance of shipments at quite high levels, inventories at United States furnace yards increased by about 17 per cent from 48.5 million tons in 1974 to 56.8 million tons in 1975. Pellet consumption continues to increase in the United States steel industry and now accounts for over 60 per cent of total iron ore consumed.

Most iron ore mines in the United States are captively-owned by steel companies and/or merchant ore companies. This vertically integrated market structure renders pricing somewhat artificial, with all transactions being normally conducted according to a reference pricing schedule called the Lake Erie Base Price. The price schedule applies directly to ores emanating from mines in the eastern U.S.A. and eastern Canada, and also provides a guideline price for offshore deliveries from Brazil, Liberia and Venezuela. The price is often established at the beginning of the year by one of the merchant ore companies, usually The Hanna Mining Company or The Cleveland-Cliffs Iron Company, which act as price leaders. In recent years the distortionary effect of United States wage-price controls and inflation have resulted in several price realignments throughout the year. In 1975 the Lake Erie base price increased on two occasions, resulting in a 17 per cent increase in iron ore prices during the year.

European market

In Western Europe iron ore is obtained through a variety of transactions including captive domestic

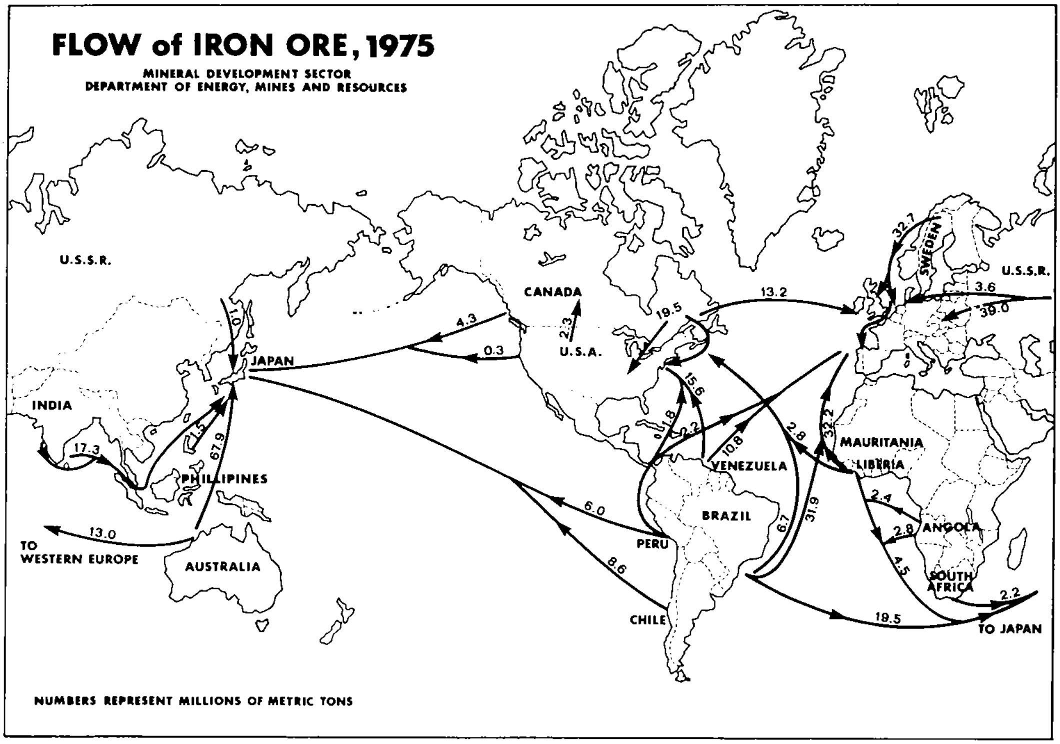


Table 8. Fob prices of selected Japanese iron ore imports, 1974-76

Country	Company	Annual Tonnage	Product Type	Grade	Price	Effective Date
				% Fe	($U.S. per long ton)	
Angola	Cia Mineira do Lobito	2,600,000	Lumps	62-64	11.53	October 1974
			Fines	62-64	9.66	October 1974
Brazil	Cia Vale do Rio Doce (CVRD)	17,440,000	Lumps	64-66	11.21-13.80	April 1975
			Fines	64	10.70	April 1975
			Sinter-feed	64-66	9.86-12.00	April 1975
	Mineraçaos Brasileiras Reunidas S.A. (MBR)	7,000,000	Lumps	64-66	12.45	November 1974
			Sinter-feed	64-66	10.65	November 1974
			Pellet ore	64-66	12.95	November 1974
Canada	Iron Ore Company of Canada	5,000,000	Fines	65	10.80	January 1975
	Texada Mines Ltd.	400,000	Sinter-fines	60-62	10.82	January 1975
	Wesfrob Mines Ltd.	400,000	Sinter-fines	60-61	10.55	January 1975
		500,000	Pellet-fines	65	11.17	January 1975
Chile	Cia de Acero del Pacifico (CAP)	7,800,000	Lumps	60-62	10.24-10.40	September 1974
			Fines	59-62	8.02- 8.21	September 1974
			Run-of-mines	60-62	10.18	September 1974
India	Chowgule & Co. Pvt. Ltd.	550,000	Pellets	65-66	19.75	April 1975
		500,000	Lumps	59	9.83	April 1975
		400,000	Fines	61-62	8.57	April 1975
Mauritania	Société National Industrielle et Minière (S.N.I.M.)	2,000,000	Fines	65-66)	10.70	January 1975[1]
		200,000	Lumps	56-58)		
New Zealand	Marcona Corp. (Waipipi iron sand)	1,200,000	Iron sand	56-58	5.95	September 1974
	New Zealand Steel Co. (Tahoroa iron sand)	1,200,000	Iron sand	56-58	5.95	September 1974
Peru	Marcona Corp.	4,000,000	Pellets	65	13.15[2]	September 1974
			Sinter-feed	58-63	6.80-10.07[2]	September 1974
			Slurry	. .	8.60[2]	September 1974

South Africa	South African Iron &Steel Industrial Corp. (ISCOR)	400,000	Lumps	63-65	12.61	October 1974
		1,400,000	Lumps	64-66	11.70	January 1976[3]
		600,000	Fines	63-65	8.73	January 1976[3]
Swaziland	Swaziland Iron Ore Development Co. (SIODC)	2,000,000	Lumps	61-63	11.82	January 1975
			Fines	61-63	8.43	January 1975
U.S.S.R.	VO Soyuzpromexport (Krivoi Rog iron ore)	350,000	Low-grade fines	55-57	7.15	January 1975
		400,000	Concentrate fines	60-62	7.95	January 1975

Source: *Japan Commerce Daily* and others.
[1]Contracts under renegotiation; [2]Calculated from cif price, assuming freight cost of $5.75 per ton; [3]Shipments due to commence in 1976 from Saldanha Bay Development.

mines, captive foreign mines, spot purchases, short- and long-term contracts. The importance of captive domestic supplies has been diminishing in recent years, especially in Luxembourg, the United Kingdom and West Germany, due to depletion of indigenous low-grade ores and more favourable blast furnace economics using higher-grade imported ores. Low-grade ores are still mined extensively in France and are an important feed material for the steel industry in France, Belgium and Luxembourg. Until 1973 about 60 per cent of all iron ore transactions in western Europe were conducted as short annual or bi-annual contracts. Although this remains the prevalent contract arrangements with Swedish iron ore exports, iron ore shipments from many non-European countries such as Australia, Brazil and Canada are often negotiated on a long-term basis with respect to tonnages. Lock-in price clauses are not now included in long-term contracts because of the prevalence of worldwide inflation in recent years, and price negotiations are normally held annually prior to the commencement of the shipping year.

Sweden has classically assumed the role of price leader in the European market, but its recent aggressive approach for price increases, a large increase in offshore imports of iron ore and scale economies in ocean shipping are beginning to lead to changes in marketing and pricing patterns in Western Europe. The large increase in Brazilian iron ore shipments and continuing strong growth rate in the medium term is leading to the emergence of Brazil as a price leader, especially in the large West German market. Despite obvious disadvantages in regard to transportation costs, Australia is also attempting to gain a much larger share of the European market, thereby reducing its assymmetrical dependence on the Japanese market. Canada, Venezuela, India, Mauritania and Liberia also ship significant quantities of iron ore to various western European countries.

A paradoxical situation in the European market in 1975 was significant increases in iron ore prices in the face of declining demand and shipment cutbacks. Most of these price increases were negotiated at the end of 1974, however, before a real appreciation had been gained of the magnitude of the world recession in 1975. In many cases iron ore prices in 1975 were 40 to 60 per cent higher than during the preceding year. Malmexport A.B., the sales agent for Swedish iron ores, negotiated substantial increases in the West German market with low-phosphorus sinter fines increasing from 24-26 cents in 1974 to 34-36 cents in 1975; low-impurity lumps from 30-32 cents to 40-41 cents; and pellets from 35-37 cents to 53-55 cents per iron unit cif Rotterdam. In late 1975 Malmexport A.B. reached agreement with the Belgian steel federation (Groupment des Hauts Fourneaux) on iron ore prices after protracted negotiations. The outcome was a 43 per cent price increase on Swedish phosphoric iron ore, with the price rising from the 1974 level of $11.00 a ton to $15.75 a ton in 1975. According to UNCTAD's* Monthly Commodity Price Bulletin, Lac Jeannine concentrates of Quebec Cartier Mining Company increased about 25 per cent in 1975 from an average monthly price of $17.15 a metric ton in 1974 to $21.16 a metric ton in 1975, cif North Sea ports. Ores from Brazil, Liberia and Venezuela also showed variable but significant price increases in the European market in 1975. Shipment cubtacks were substantial in 1975, with the intake of high priced Swedish ores being notably reduced. Whereas Swedish exports of iron ore attained 33.2 million metric tons in 1974, these were reduced markedly in 1975 to 23.2 million metric ton. In an attempt to maintain or increase the price of iron ore products Sweden took firm action on the stockpiling of iron ore in 1975. The state-owned iron ore company, Luossavaara-Kiirunavaara Aktiebolag (LKAB) financed stockpiles of iron ore at both producer and consumer locations. The company has already stockpiled to capacity at its major shipping ports of Narvik, Norway (2.3 million tons) and Lulea, Sweden (2 million tons), and is embarking upon a stockpile scheme of at least one million tons of iron ore at Rotterdam in the Netherlands to make ore readily available to continental steelmakers for the expected ultimate upturn in steel demand.

Table 9. Representative fob prices of Australian lump and fines according to Japanese contracts, 1966-1975

	Hamersley		Goldsworthy		Mt. Newman	
	Lump	Fines	Lump	Fines	Lump	Fines
	($U.S. per dry long ton, 64% Fe basis)					
1966-67	9.92	7.68	9.86	7.25	. .	. .
1968	9.37	7.68	9.37	7.68	9.37	7.13[1]
1969	9.37	7.63	9.37	7.68	9.37	7.13[1]
1970	9.58	7.23[1]	9.86	7.95	9.58	7.23[1]
1971	9.58	7.95	9.58	7.25[1]	9.58	7.25[1]
1972	9.38	7.68	9.38	7.68	9.38	7.68[1]
1973	10.96	8.68	10.96	8.68	10.96	8.45[1]
1974	13.21	10.93	13.21	10.93	13.21	10.70[1]
1975[2]	14.20	11.69	14.20	11.75	14.20	10.90[1]

Source: *Japan Commerce Daily* and others.
[1]62% Fe. [2]New prices applicable to some contracts only — 1974 prices retained on other contracts.
. . Not available.

For deliveries of iron ore to major western European steel companies in 1976 it appears that many iron ore countries have accepted a 5 to 10 per cent cut in price, partly a reflection of the serious financial positions of many European steelmakers. Cia Vale do Rio Doce (CVRD) of Brazil, however, reached agreement

* UNCTAD — United Nations Conference on Trade and Development.

with the West German steel industry for substantial increases for iron ore shipments in 1976. Average prices for iron ore will increase by 28.5 per cent over 1975 levels, mainly a reflection of the low prices paid for Brazilian ore during 1975. By year-end 1976 these increases will raise the price of Brazilian sinter feed to $16.00 a metric ton; pebbles to $18.56 a metric ton; and natural pellets (lumps) to $20.48 a metric ton, all on an fob basis. It is believed that the high price increases were accepted by the West Germans in return for substantial shipment cutbacks in 1976.

Japanese market

Despite a 13 per cent decline in steel production in Japan in 1975, imports or iron ore declined only 7 per cent. The decline in iron ore shipments would have been even less had not political and other problems disrupted shipments from Angola, Peru and Mauritania. The less-than-proportionate decline in iron ore shipments compared with steel production did result in a large increase in inventories at Japanese furnace yards. Iron ore imports in 1975 were 132 million metric tons valued at $2.2 billion compared with 142 million metric tons valued at $2.0 billion, on a cif basis. The average cif price of iron ore increased by 14 per cent from $14.25 a metric ton in 1974 to $16.24 a metric ton in 1975.

Australian iron ore producers are the recognized price leaders in the Japanese market, due to favourable locational economics. In 1975 imports of Australian iron ore accounted for 48 per cent of total Japanese iron ore imports, although 1975 shipments of 63.3 million metric tons fell below the 1974 level of 67.9 million metric tons. On the other hand Brazilian imports rose appreciably from 19.5 million metric tons in 1974 to 23.5 million metric tons in 1975, a trend which will be intensified in the medium term with the Brazilian policy of using iron ore exports as a major weapon to assist a chronic deficit trade balance.

Other major iron ore exporters to Japan in 1975 were India (16.8 million metric tons) and Chile (8.1 million metric tons). Canada is not a major exporter of iron ore to Japan, because of unfavourable transportation economics from Canada's major producing region at Quebec-Labrador to Japan. Shipments of 3.9 million tons in 1975 emanated mainly from the Iron Ore Company of Canada, with subsidiary shipments from the two iron ore producing mines in British Columbia. Canadian shipments of iron ore to Japan are expected to remain quite stable in the long term, and will comprise almost entirely IOC's long-term contract shipments to 1988. In 1975 Japan imported iron ore from a total of 22 countries in an attempt to play suppliers against one another and hold prices as low as possible. This policy has been successful to date with the Japanese obtaining their iron ore at markedly lower fob and cif prices than the United States or European consumers. Recent trends in prices, however, indicate that this gap may be closed substantially in the near future.

Prices increased somewhat in the Japanese market in 1975, but most of the major price realignments were negotiated in the fall of 1974. Canadian iron ore prices were increased at the beginning of 1975. Concentrate shipments from Wesfrob Mines Limited and Texada Mines Ltd. were increased by U.S. $1.70 a long ton to $10.82 and $10.55 respectively for sinter fines. Carol Lake concentrate from IOC was increased by $2.25 a ton from 16.4 cents c&f per Fe unit to 19.81 cents c&f per Fe unit.

Despite recession conditions and huge Japanese inventories of iron ore, exporting countries were striving forcefully for large price increases in late 1975 and early 1976. The pressure for significant price realignments was finally successful when the Australians extracted large increases in April 1976. Both Hamersley Iron Pty. Ltd. and Mt. Newman Mining Co. Pty. Ltd. achieved general price increases averaging about 19 per cent annually over the next two years. The increases will occur in four semi-annual stages; zero per cent in the first half of fiscal 1976, 15 per cent in the second half of fiscal 1976, 20 to 30 per cent in the first half of fiscal 1977 and 25 to 35 per cent in the second half of fiscal 1977. These price increases are expected to form the basis for higher prices to other Australian producers and other iron ore exporters in the Japanese market in 1976-77.

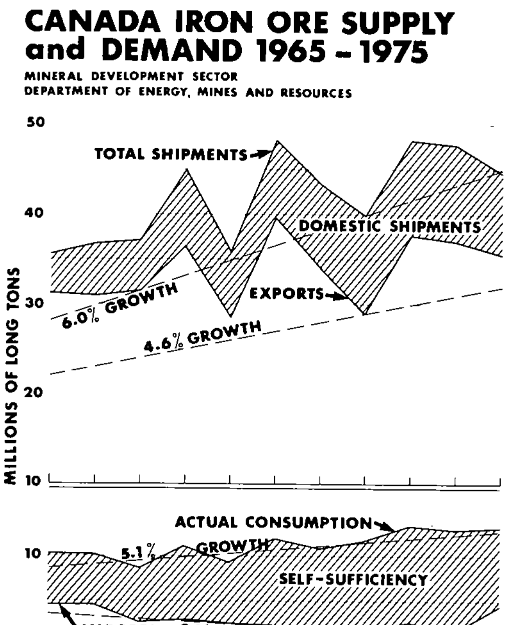
In order to preclude short term disruptions in iron ore supply, Japan is currently studying the concept of larger scale stockpiling of iron ore. One Japanese steel company, Kawasaki Steel Corp., has already embarked upon construction of a stockyard to hold 2 million tons of iron ore products, an amount sufficient to last about one and a half months at present consumption rates. Kawasaki is presently negotiating with other Japanese steel companies relating to participation in Kawasaki's plan to construct and operate a mammoth iron ore stockpiling centre at Mindanao, Philippines. The project, which will be subject to approval by the Philippine government, envisages a stockpile complex of 10 million tons of iron ore products from Australia for delivery to coastal, integrated steelmakers in Japan. The tonnage equals 25 days of reserves for Japanese integrated steel mills. Present stock capacities are limited to about one and a half month's consumption equivalent, but the Japanese want to boost this reserve to at least three months, enabling them to forestall short-term interruptions in iron ore supply.

Future trends

The immediate outlook for the Canadian iron ore industry is good as new projects and recent expansions approach their full rated capacity. Given an expected, albeit slow, world economic upturn in 1976, Canadian iron ore shipments should increase from 44.8 million tons in 1975 to about 55 million tons in 1976. As the new Quebec-based projects at Mount Wright and Fire

Lake attain rated production capacity, Canadian iron ore production is expected to increase to 68 million tons in 1980. Following attainment of rated capacity at these mines, however, the Canadian iron ore industry will enter a period of marked stagnation and a significant decrease in the number of iron ore producers. Many of the smaller operations; Hilton Mines, Texada Mines Ltd., Marmoraton Mining Company, National Steel Corporation of Canada, Steep Rock Iron Mines Limited, Caland Ore Company Limited and Wesfrob Mines Limited, are expected to cease production before 1980, or close thereafter due either to depletion of ore reserves or the escalation of operating costs to untenable levels. In the longer term, continued growth in the Canadian iron ore industry is expected due to the existence of a large, proven resource base, strong demand from major steel producing countries and a stable investment climate, with production (shipments) rising to possibly 100-105 million tons by 2000.

The growth of the Canadian iron ore industry will continue to be primarily in response to export demand, especially in the United States and European markets. Export demand currently accounts for 80 per cent of total shipments, and the high export component of total Canadian shipments is expected to be retained, or even increased slightly, in the long term. Shipments to Europe may increase at a faster rate of growth than shipments to the United States in the medium term, as European steelmakers make increasing commitments to Canadian iron ore supplies and the United States steel companies continue to develop indigenous ore deposits in preference to Canadian ore deposits.



Domestic shipments of iron ore to the large integrated steel producers in Ontario will also decline in relation to imports in the medium term as Ontario steel companies make increasing equity commitments in United States projects for procurement of future ore supplies. This trend will continue until a more favourable economic climate for iron ore development is established in Canada.

Shipments by the Canadian steel industry in 1975 were 14.4 million short tons and these are expected to increase to 19.1 million short tons in 1980. Iron ore consumption will increase correspondingly, from 14.3 million short tons in 1975 to 19.4 million short tons in 1980. Of total consumption, 12.8 million short tons will be of domestic origin, and 6.6 million short tons will be imported, mostly from the United States.

The large dependence of Canadian iron ore shipments on export demand assumes continued growth in world steelmaking, especially in the industrialized, developed countries. Despite the severe recession in the noncommunist world steel industry in 1975, steel production is expected to expand at a 5 to 6 per cent growth rate over the next few years and attain 905 million metric tons in 1980 and about 1,030 million metric tons in 1985. Although part of this growth will occur in less - developed countries such as Brazil, India and Venezuela with large indigenous supplies of ore, the steel industries in Japan, the United States and many western European countries will continue to experience moderate growth rates. These large industrialized nations will generally become increasingly dependent on imported iron ores and thus the growth rate in world iron ore trade will continue to outstrip the growth rate in world iron ore production.

The future demand for iron ore will also be influenced by continuing changes in steelmaking technology. The trend to the replacement of open-hearth furnaces by basic oxygen furnaces is expected to continue unabated in the next decade, and the higher pig iron-to-scrap ratio of basic oxygen furnaces compared to open hearth will lead to an increasing demand for pig iron, and hence iron ore. This is expected to be counterbalanced to some extent by strong growth in electric steelmaking which will create a strong demand for scrap. The projected tight supply or shortages of scrap in the medium term and strong growth of electric steelmaking in many scrap-deficient, less-developed countries is expected to lead to strong growth in direct reduction processing. The increasing dependence of many electric steelmakers upon direct reduced iron will lead to an increasing demand for high quality iron ores. Scrap shortages are expected to be further aggravated by a strong trend to continuous casting which will lead to the generation of less process scrap and to greater pressure on the obsolete scrap market. The historical world pig iron to steel ratio has remained quite constant at 0.71, but because of the aforementioned trends in steelmaking technology and iron raw materials consumption, this ratio is projected to increase to 0.74 in 1980. Thus pig iron and direct reduction processing is expected to increase from 507 million metric tons in 1974 to 670 million metric tons in 1980. Assuming a 92 per cent iron content in the metallic iron products, this is equivalent to a total iron content in iron ores of 616 million metric tons in 1980. This, translated into iron ore requirements for 1980, is approximately 1050 million metric tons of iron ore products. This is equivalent to a 4.5 per cent annual growth rate in iron ore production over the next five years.

The growth rate in iron ore trade will continue to outstrip the growth rate in iron ore production and should approximate 7 per cent annually. Iron ore trade is thus expected to increase to 560 million tons in 1980, largely in response to incremental growth in steel activity in Japan and European countries, and to a lesser extent the United States and Middle East countries.

The vast global reserves of iron ore have always been reflected in an abundance of iron ore to meet world steel demand in past years, with the exception of some temporary shortages during the peak demand period of 1973-74. In turn, this was reflected in stable or declining iron ore prices throughout the 1960s and even into the early 1970s. Since about 1973, however, various factors have led to some major changes in iron ore supply considerations. These include the large escalation in costs of iron ore projects induced by inflation and increasing consumer demands for beneficiated and/or agglomerated ores. This, in conjunction with a hostile investment climate in several iron ore exporting countries and increasing diversion of iron ore to domestic steel industries, is expected to lead iron ore exports to a retarded rate of development in the long-term. Thus, despite the undoubted abundance of iron ore reserves in the ground, the developments of new projects may be insufficient to preclude periodic shortages, or at least a tight supply situation, in the long term. Many major projects are already being delayed substantially or held in abeyance indefinitely in Australia, Brazil, Ivory Coast, Gabon, Guinea, Bolivia and Liberia. The enormous costs of transportation and social infrastructure in many of these countries will be a substantial obstacle to the development of iron ore reserves. Furthermore, the consuming countries are beginning to economize on blast furnace investment by increasing their efficiency through the use of iron ore materials with superior physical and chemical characteristics. Thus economies in blast furnace investment in many consuming countries will inflict even larger capital investments in beneficiation and/or agglomeration facilities in iron ore producing countries. In addition, the growth in direct reduction processing will engender a strong demand for premium quality iron ore products containing a high iron content and low deleterious gangue constituents such as silica and alumina. The cost and time lags involved in the emplacement of new capacity will undoubtedly lead to a perpetuation of the significant price increases which have characterized the iron ore market over the past three years.

The Association of Iron Ore Exporting Countries is not expected to affect profoundly iron ore trading patterns or marketing procedures in the medium term, in part because many major iron ore exporting countries, viz. Brazil, Canada, Liberia and South Africa, are not members. The mere existence of the group, however, and a more cooperative approach by exporting countries in the face of consumer demands will result in significant increases in prices in the long term. As the bargaining power between iron ore exporters

Table 10. Selected iron ore supply-demand statistics, 1970, 1974, 1975 and forecast to 2000

Year	Raw Steel Production	Iron Ore Consumption[1]	Imports	Domestic Shipments	Exports	Total Shipments
	(net tons)		(long tons)			
1970	12.3	11.5	2.1	9.2	38.6	47.8
1974	15.0	13.3	2.3	10.6	37.0	47.6
1975	14.4	13.0	4.8	9.2	35.5	44.6
1976	15.0	13.8	4.5	9.3	45.7	55.0
1977	16.2	14.9	5.4	9.5	49.5	59.0
1978	17.2	15.8	5.4	10.4	51.6	62.0
1979	18.2	16.7	5.7	11.0	54.0	65.0
1980	19.1	17.6	6.0	11.6	55.9	67.5
2000	33.0	30.4	9.0	21.4	83.6	105.0

Source: Mineral Development Sector, Department of Energy, Mines and Resources, Ottawa.
[1]For the period 1970-75 actual consumption does not equal apparent consumption because of changes in stock levels.

and major consuming countries becomes more evenly distributed the concept of a commodity agreement for iron ore might become appealing. This could lead to a more orderly development of iron ore reserves and the marketing of iron ore products, precluding the deleterious pricing fluctuations and inequities which have alternately beleagured producers and consumers in past years.

Iron and Steel

PAUL LAFLEUR

An economic recession throughout most of 1975 had a pronounced effect on the Canadian steel industry. The extreme sensitivity of steel consumption to business cycle movements was demonstrated when a moderation in the growth of real Gross National Product (G.N.P.) from 2.8 per cent to 0.2 per cent induced a decline in apparent rolled steel consumption of about 16.2 per cent. This was the largest decrease recorded since 1958. The decreased G.N.P. growth rate gave rise to major adjustments in all the elements of steel demand and supply. Accordingly, mill shipments were down by 8.6 per cent from the previous year while crude steel* production decreased by about 4.4 per cent. Imports slumped by 52 per cent, reflecting lower domestic demand and other factors. Exports were down 32 per cent to reflect a contemporaneous economic recession in most countries, particularly in the United States which is Canada's largest market.

Despite the downturn in steel production, the steel industry continued to expand. Steelmaking capacity, which stood at 18.3 million tons** at the beginning of 1975, rose by some 2.7 per cent to 18.8 million tons.

Steel prices continued to rise in 1975 reflecting increased costs of labour and raw materials. Despite the price rise, Canadian prices remained lower than United States steel prices. Some countries, faced with low domestic demand, resorted to price cutting to encourage exports and this led to allegations of dumping by Canada and some other countries.

A major reversal in total world steel demand occurred during 1975 when the market economy countries experienced a most serious economic recession. However, the situation was very different in planned economy countries where steel production increased by 6 to 7 per cent to reflect buoyant demand and new government investment.

From a basic reflection of the positive outlook for the Canadian economy, apparent steel consumption is expected to increase in 1976 by about 4.1 per cent. Accordingly, producer shipments will be up by an estimated 4.3 per cent, while raw steel production is forecast to increase by 4.5 per cent. The trade pattern will reflect a slow economic recovery in Canada and the United States that is not expected to gain momentum until the latter half of the year.

The medium- to long-term outlook for the Canadian steel industry appears good. Raw steel consumption is forecast to be 20.8 million tons in 1980, 25.6 million tons in 1985 and 35.5 million tons in 2000. This compares with forecasts of producer shipments of 19.1 million tons in 1980, 23.2 million tons in 1985, and 33.0 million tons in 2000. In terms of raw steel, the imbalance in trade favouring imports will amount to 1.7 million tons in 1980 and 2.4 million tons in both 1985 and 2000.

Production, consumption and trade

With a decline in the growth rate of real GNP in 1975, apparent rolled steel consumption decreased by 2.1 million tons to 10.9 million tons. The main element of supply, domestic shipments (producer or mill shipments less mill exports), amounted to about 9.5 million tons, down 5.2 per cent from the previous year, while imports, at 1.5 million tons, registered a decline of 52 per cent.

In accordance with normal practice during any downward phase of the economic cycle, warehouses and steel service centres reduced their stocks substantially, especially stocks of high-cost imports left over from 1974, which was a relatively good year. On the other hand, user stocks, which were severely depleted in the previous year as a result of high outputs, were brought up to, or above, normal levels to provide a hedge against a possible labour strike at steel mills in mid-year. However, the excess stock situation was short-lived because a strike-free settlement was negotiated and users reduced buying from mills to use up inventory.

* Crude steel comprises ingots, semis and steelcastings.

** The net or short ton (2,000 pounds) is used throughout, unless otherwise stated.

Producer or mill shipments were down from 1974 by 8.6 per cent to 10.5 million tons to reflect an 8.0 per cent fall in domestic shipments and a 32 per cent decline in exports, mainly resulting from depressed economic conditions in the United States, Canada's largest customer.

Among domestic steel-consuming industries, the automotive and construction industries together accounted for about two thirds of the total decline in domestic demand, while the appliance, wire products and container industries also took much less steel as a result of production cutbacks. Because of lower activity in the construction industry during most of the year, shipments of structural shapes and concrete reinforcing bars were down by 10 and 21 per cent, respectively. A reduction of about 18 per cent in shipments of cold-reduced sheet and strip is attributable mainly to the low level of activity in the automobile and appliance industries. On the positive side, demand in the pipe and tube, and agricultural implement industries showed moderate growth. The performance by this group of consumers was mainly responsible for the 12 per cent increase

Table 1. Canada, general statistics of the domestic primary iron and steel industry, 1973-75.

		1973	1974	1975^p
Production				
Volume indexes				
Total industrial production	1971=100	115.8	118.9	113.4
Iron and steel mills[1]	1971=100	117.6	123.0	111.1
		($ million)	($ million)	($ million)
Value of shipments, iron and steel mills[1]		2,287.4	2,878.8	2,985.1
Value of unfilled orders, year-end, iron and steel mills[1]		433.2	579.1	517.3
Value of inventory owned, year-end, iron and steel mills[1]		459.1	613.4	852.2
Employment, iron and steel mills[1]		(number)	(number)	(number)
Administrative		11,806	10,280^p	10,700*
Hourly rated		41,202	42,240^p	41,800*
Total		53,008	52,520^p	52,500*
Employment index, all employees	1961=100	146.8	142.8	143.9*
Average hours per week, hourly rated		40.0	39.9	39.3*
		($)	($)	($)
Average earnings per week, hourly rated		197.39	214.08	226.62*
Average salaries and wages per week, all employees		205.81	221.52	241.26*
		($ million)	($ million)	($ million)
Expenditures, iron and steel mills[1]				
Capital: on construction		32.1	70.3	158.8
on machinery		206.0	296.6	524.3
Total		238.1	366.9	683.1
Repair: on construction		20.5	22.9	27.8
on machinery		228.1	269.4	317.9
Total		248.6	292.3	345.7
Total capital and repair		486.7	659.2	1,028.8
Trade, primary iron and steel[2]				
Exports		355.3^r	589.6^r	663.5
Imports		579.5	1,172.7	842.6

Source: Statistics Canada.
[1] S.I.C. Class 291 — Iron and Steel Mills: covers the production of pig iron, steel ingots, steel castings, and primary rolled products, sheet, strip, plate, etc. [2] Includes pig iron, steel ingots, steel castings, semis, hot- and cold-rolled products, pipe and wire. Excludes sponge iron, iron castings and cast iron pipe. Compiled by Mineral Development Sector, Department of Energy, Mines and Resources, Ottawa.
^{p} Preliminary; ^{r} Revised; *8-month average.

in plate shipments as well as for limiting the decline in hot-rolled sheet and strip shipments to approximately two per cent.

Production of crude steel was cut back sharply by 4.4 per cent to 14.4 million tons. The reduction was not as severe as the 8.6 per cent decrease in producer shipments because of a buildup of about 200,000 tons of rolled steel at steel plants to bring inventory up to normal levels. The year opened on an optimistic note as the downturn in the Canadian economy in the last quarter of 1974 had not yet affected steel demand. This was evident in the construction industry, the largest consumer of steel, which did not immetiately feel the sudden downturn in the economy because of forward commitments. Optimism was buoyed up by hedge buying in anticipation of a possible labour strike at two major steel plants in mid-year. During the first half of 1975, production of crude steel and castings was 2.8 per cent higher than in the first half of 1974. However, continued depressed economic conditions took its toll and, with the halting of hedge buying, and dwindling exports, production decreased from the previous year by as much as 8.6 per cent in the third quarter and 9.8 per cent in the fourth quarter.

Notwithstanding the sharp decrease in production and its consequent effect on profits, installation of new facilities and improvement of operating facilities set a fast pace during the year. However, steelmaking capacity rose only moderately by some 2.7 per cent to 18.8 million tons at year-end. Open-hearth steelmaking

Table 2. Canada, pig iron production, shipments, trade and consumption, 1973-75

	1973	1974	1975^p
		(net tons)	
Furnace capacity, January 1[1]			
Blast	10,410,000	10,470,000	11,025,000
Electric	705,000	675,000	675,000
Total	11,115,000	11,145,000	11,700,000
Production			
Basic Iron	9,627,429	9,564,449	9,466,064
Foundry iron	883,565	821,857	620,079
Malleable iron	*	*	*
Total	10,510,994	10,386,306	10,086,143
Shipments			
Basic iron	63,594	123,153	91,793
Foundry iron[2]	952,433	827,963	551,432
Total	1,016,027	951,116	643,225
Imports			
Net tons	2,052	2,472	4,495
Value ($'000)	183	455	884
Exports			
Net tons	641,987	570,381	447,834
Value ($'000)	40,768	61,179	78,202
Consumption of pig iron			
Steel furnaces	9,515,584	9,590,811	9,364,237
Iron foundries	348,907	339,037	295,967
Consumption of iron and steel scrap			
Steel furnaces	7,493,341	7,701,647	7,288,704
Iron foundries	1,366,625	1,365,541	1,237,685

Sources: Statistics Canada. *Primary Iron and Steel* (monthly); *Iron and Steel Mills* (annual) and *Iron Castings and Cast Iron Pipes and Fittings* (monthly).
[1] The capacity figures as of January 1 in each year take into account both new capacity and obsolete capacity anticipated for the year. [2] Includes malleable iron.
* Included under "Foundry iron".
^{p} Preliminary.

capacity remained at the previous year's level of 4.13 million tons a year, while basic oxygen furnace and electric steelmaking capacities were raised by 176,000 tons and 234,000 tons a year to 10.13 and 4.10 million tons, respectively.

Steelmaking is widespread in Canada, but the large plants are concentrated mostly in Ontario. Of the 44 plants* making steel, five are integrated plants and 39 are electric steel and castings facilities. Of the six pig iron plants in Canada, four are part of integrated complexes which have backward linkages into iron ore and coal production and forward linkages into manufacturing and fabrication. Two are at Hamilton, Ontario and one each is at Sault Ste. Marie, Ontario, and

Table 3. Canada, crude steel production, shipments, trade and consumption, 1973-75

	1973	1974	1975^p
		(net tons)	
Furnace capacity January 1[1]			
Steel ingot			
Basic open-hearth	5,830,000	4,125,000	4,125,000
Basic oxygen converter	6,730,000	9,950,000	10,126,000
Electric	2,977,800	3,865,800	4,100,000
Total	15,537,800	17,940,800	18,441,000
Steel castings	436,525	393,900	397,500
Total furnace capacity	15,974,325	18,334,700	18,838,500
Production			
Steel ingot			
Basic open-hearth	4,608,197	3,775,659	3,394,143
Basic oxygen	7,433,896	8,106,525	8,052,297
Electric	2,507,127	2,913,256	2,671,716
Total	14,549,220	14,795,440	14,118,156
Continuously cast in total	1,709,682	2,031,758	1,917,059
Steel castings[2]	206,159	221,838	239,312
Total steel production	14,755,379	15,017,278	14,357,468
Alloy steel in total	1,546,231	1,674,046	1,374,626
Shipments from plants			
Steel castings	191,617	208,292	215,004
Rolled steel products	10,935,708	11,439,226	10,452,097
of which steel ingots are	388,853	500,995	399,575
Total	11,127,325^r	11,647,518	10,667,101
		(000 net tons)	
Exports, equivalent steel ingots	1,752.2^r	1,812.9	1,281
Imports, equivalent steel ingots	2,589.3^r	3,974.0	1,888
Indicated consumption, equivalent steel ingots	15,592.5^r	17,178.4	14,964

Source: Statistics Canada.
[1] The capacity figures as of January 1 in each year take into account both new capacity and obsolete capacity anticipated for the year. [2] Produced mainly from electric furnaces.
^{p} Preliminary; ^{r} Revised.

* A complete listing of Canadian Primary iron and steel plants including steel foundries is in the publication Operators List 2, *Primary Iron and Steel.* It is available from Publishing Centre, Department of Supply and Services, Ottawa, Canada.

Sydney, Nova Scotia. The two other pig iron plants — Quebec Iron and Titanium Corporation and the Port Colborne facilities of The Algoma Steel Corporation, Limited — make iron either for use in foundries or for the production of iron powder. They are, therefore, not considered as integrated steel production facilities, since the pig iron is not converted to steel. A fifth, but unconventional, type of integrated plant was added in 1973 with the start up of Sidbec-Dosco Limited's new direct-reduction plant which converts iron ore to reduced iron for use in electric furnaces.

Investment and corporate developments

The Canadian steel industry had record expenditures in 1975, thereby indicating its continued confidence in the medium- to long-term possibilities for growth in steel demand. Capital and repair expenditures in 1975 for iron and steel mills amounted to $1.0 billion compared with $695 million the year before. See Table 1. Notwithstanding an inflation rate of nearly 10 per cent during the year, expenditures increased dramatically to reflect massive investments in new plant facilities. Repair expenditures comprised some 34 per cent of the total and this amounted to $24.08 per ton of ingot steel produced. With several major projects either underway or announced, capital expenditures promise to be large also in 1976.

The Steel Company of Canada, Limited (Stelco), the largest steel producer in the country, increased its expenditures by 72 per cent to $233 million, a record for the company. It allocated about half of its capital expenditures to the continued construction of its new steel complex at Nanticoke, Ontario. Most of Stelco's remaining investment went for an iron ore mining project at Hibbing, Minnesota, a direct reduction kiln at The Griffith Mine in northwestern Ontario, and a rod processing plant at its Hamilton, Ontario Hilton Works.

The first stage of the Nanticoke project, which was begun in 1974, is expected to be completed in 1978 at a total cost of $900 million, more than double the cost originally anticipated. The sharp rise in costs is in line with the tremendous increase in construction costs for major engineering projects throughout Canada. Installations scheduled for completion as part of the first phase include a blast furnace, two basic oxygen furnaces, a double-strand continuous casting machine for steel slabs, and an 80-inch continuous hot-strip mill. The initial steelmaking capacity will be 1.3 million tons a year, but additional modules will be added later to raise capacity to six million tons. This final configuration will probably be reached in the 1980s.

Stelco completed construction of iron ore reduction facilities at its Griffith Mine in northwestern Ontario. The SL/RN direct-reduction process will convert a portion of the high-quality oxide pellets produced at the mine to a reduced product grading as high as 92 per cent iron. This product, amounting to 400,000 tons a year, will be used as a supplement to the scrap charge in Stelco's new steelmaking plants at Contrecoeur, Quebec and Edmonton, Alberta.

The Algoma Steel Corporation, Limited (Algoma) also had a major investment program underway in 1975, but expenditures at $105 million were down 24 per cent from 1974 with the completion of some major facilities. Installed were a 5,000-ton-a-day blast furnace

Table 4. Producer shipments[1] of rolled steel[2], 1974-75

	(000 net tons)		
	1974	1975	% Growth
Ingots and semis	501.0	399.6	−20.2
Rails	317.0	371.5	+17.2
Wire rods	858.1	630.8	−26.5
Structural shapes	804.4	726.5	− 9.7
Concrete reinforcing bar	772.1	611.5	−20.8
Other HR bars	1,073.1	950.4	−11.4
Track material	77.8	87.2	+12.1
Plate	1,412.7	1,605.5	−13.6
Hot rolled sheet and strip	2,504.1	2,458.1	− 1.8
Cold finished bars	102.8	88.0	−14.4
Cold reduced sheet, strip, other and coated	2,044.3	1,678.6	−17.9
Galvanized sheet and strip	971.8	844.3	−13.1
	11,439.2	10,452.1	− 8.6
Alloy steel in total shipments	738.6	752.0	+ 1.8

Source: Statistics Canada. *Primary Iron and Steel* (monthly).

[1] Includes producer exports. [2] Includes ingots and semis, but not steel castings; comprises both carbon and alloy steels.

and a 1,500-ton-a-day coke oven battery. Hot-metal capacity was thereby increased to effectively raise the company's steelmaking capacity to 4.3 million tons, the second largest among Canadian producers.

Algoma has a 2-strand continuous slab caster under construction that will provide slabs up to 12 inches thick and from 40 to 85 inches wide. Initial output is expected to be about 750,000 tons a year. It will be on line with a 166-inch plate mill which can either produce plate or act as the roughing mill for the 106-inch, hot strip mill that was relocated downstream from the plate mill in late 1974.

Dominion Foundries and Steel, Limited (Dofasco) had expenditures totalling $117 million for expansion and improvement in 1975. Installation of a 5-stand, 72-inch tandem cold-rolling mill progressed during the year and will be commissioned in early 1976 to increase the company's cold-rolling capacity to 180,000 tons a month. The No. 1 blast furnace, shut down in 1971, was rebuilt at a cost of $17 million. This will increase the company's ironmaking capacity by 20 per cent. A desulphurizing station for treatment of hot metal was also completed.

In early 1975 Dofasco announced that construction will begin on a new $103 million steelmaking shop in Hamilton. This represents the first phase of the company's plans to double steelmaking and finishing capacity from the three-million-ton-a-year level to beyond six million tons a year. The steelmaking shop is scheduled for completion in the latter part of 1977 and will be capable of producing 1.25 million tons of crude steel a year. At year-end, site preparation was complete and foundations were being constructed.

Sidbec-Dosco continued its major program to bring its steel production capacity in balance with its rolling capacity. As part of its Phase II program, which began in 1973, new facilities being installed include two 150-ton electric furnaces that will raise steelmaking capacity by 700,000 tons a year to 1.58 million tons a year; a second direct reduction plant to increase total reduction capacity by 650,000 tons a year to one million tons a year; and two continuous casting machines, one for slabs and the other for billets. To supply its needs for high-quality iron ore for its reduction facilities, the company announced that it will be participating to the extent of 40 per cent in the 6-million-ton-a-year Fire Lake iron ore pellet project in Quebec.

Table 5. Disposition of rolled steel products[1], 1974-75

	1974	1975	% Growth
		(net tons)	
Wholesalers, warehouses and steel service centres	1,662,246	1,487,893	−10.5
Automotive and aircraft	1,448,555	1,267,050	−12.5
Agricultural	228,378	240,717	+ 5.4
Contractors-building	781,771	617,275	−21.0
Construction-public and utility	44,378	49,801	+12.2
Structural steel fabricators	1,073,060	989,529	− 7.8
Containers	623,835	510,937	−18.1
Machinery and tools	363,570	337,379	− 7.2
Wire, wire products and fasteners	867,717	680,354	−21.6
Natural resources and extractive industries	269,747	260,969	− 3.3
Appliances and utensils	234,498	180,241	−23.1
Other metal stamping and pressing	722,501	702,709	− 2.7
Railway operating	289,935	339,417	+17.1
Railroad cars and locomotives	173,380	169,877	− 2.0
Shipbuilding	62,927	64,765	+ 2.9
Pipes and tubes	1,513,322	1,620,541	+ 7.1
Miscellaneous	107,926	71,916	−33.4
Total domestic shipments	10,427,746	9,591,370	− 8.0
Producer exports[2]	1,011,480	860,727	−14.9
Total producer shipments	11,439,226	10,452,097	− 8.6

Source: Statistics Canada. *Primary Iron and Steel* (monthly).
[1] Includes ingots and semis, but excludes steel castings, pipe and wire. [2] Total rolled steel exports amounted to 1.435 and 0.972 million tons in 1974 and 1975, respectively.

The Atlas Steels Division of Rio Algom Limited, Canada's largest producer of stainless and special steels, was involved throughout the year with a major program of expansion and improvement. The main elements of the program are the installation of two 60-ton and one 25-ton electric arc furnaces that will replace the six furnaces in use at Welland, Ontario and the addition of a third Sendzimer cold-rolling mill that will increase cold-rolling capacity by 50 per cent. To improve the quality of the stainless steel produced at its plant at Tracy, Quebec a $1.3 million oxygen degassing unit is being installed.

Most of the other steel mills had projects under way during the year to either increase efficiency or to raise capacity. The Manitoba Rolling Mills Division of Dominion Bridge Company, Limited (owned 43.5 per cent by Algoma) at Selkirk, Manitoba, finished construction of a new $28.5 million merchant bar-rolling mill that will replace two obsolete smaller mills. Ivaco Industries Limited at L'Orignal, Ontario brought its new electric furnace melt shop and accompanying continuous casting facilities on stream in mid-year with a total capacity of 270,000 tons of billets a year. QSP Ltd. completed construction of a 300,000-ton-a-year, $30-million steel

Table 6. Canada, trade in steel by product[1], 1973-75

	Imports			Exports		
	1973	1974	1975	1973	1974	1975
	(000 net tons)					
1. Steel castings (incl. grinding balls)	19.6	15.8	18.8	25.5	26.8	29.6
2. Ingots	8.5	8.2	67.1	37.7	21.2	1.2
3. Semi-finished steel blooms, billets, slabs	86.8	49.7	50.6	98.7	240.0	37.6
4. Total (1+2+3)	114.9	73.7	136.5	161.9	288.0	68.4
5. Finished steel						
A) Hot-rolled						
Rails	13.6	30.7	61.9	123.2	143.3	138.8
Wire Rods	232.9	326.0	260.9	134.3	140.5	93.9
Structurals	428.5	655.0	210.3	121.8	123.1	99.1
Bars	239.1	492.1	136.2	76.7	73.3	43.2
Track Material	3.4	7.4	12.5	13.7	8.3	2.5
Plate	311.7	600.6	381.5	212.1	192.9	169.8
Sheet and Strip	349.4	496.6	106.7	188.5	155.9	156.2
Total hot-rolled	1,578.6	2,608.4	1,170.0	870.3	837.3	703.5
B) Cold-rolled						
Bars	22.7	35.8	24.9	9.9	17.5	8.0
Sheet and strip	143.6	145.7	43.0	86.7	34.9	25.9
Galvanized	37.4	62.4	18.9	98.3	77.8	64.6
Other[1]	123.0	150.9	92.0	159.3	206.7	131.5
Total cold-rolled	326.7	394.8	178.8	354.2	336.9	230.0
6. Total finished steel (A+B)	1,905.3	3,003.2	1,348.8	1,224.5	1,174.2	933.5
7. Total rolled steel (2+3+6)	2,000.6	3,061.1	1,466.5	1,360.9	1,435.4	972.3
8. Total steel (4+6)	2,020.2	3,076.9	1,485.3	1,386.4	1,462.2	1,040.7
9. Total steel (raw steel equiv.)[2]	2,589.3	3,974.0	1,888.2	1,752.2	1,812.9	1,280.7
10. Fabricated steel products						
Steel forgings	11.2	11.0	12.0	38.7	42.2	35.0
Pipe	270.9	274.7	215.8	216.8	383.9	356.4
Wire	97.4	120.8	88.7	60.0	67.4	44.3
11. Total fabricated	379.5	406.5	316.5	315.5	493.5	435.7
12. Total castings, rolled steel and fabricated (8+11)	2,399.7	3,483.4	1,801.8	1,702.0	1,955.7	1,476.4

Source: Statistics Canada, Exports and Imports by Commodities.
[1] Includes steel for porcelain enameling, terneplate, tinplate and silicon steel sheet and strip. [2] Calculation: finished steel (row 6) divided by 0.77 plus steel castings, ingots and semis (row 4).

Table 7. Canada, value of trade in steel castings, ingots, rolled and fabricated products, 1973-75

	Imports			Exports		
	1973	1974	1975	1973	1974	1975
	($000)					
Steel castings	16,122	12,778	22,319	10,132	12,792	18,787
Steel forgings	16,496	12,278	22,329	23,248	30,927	36,234
Steel ingots	1,090	3,358	9,672	5,252	3,540	649
Rolled products						
Semis	11,005	10,919	12,603	12,765	38,942	9,858
Other	399,706	915,191	526,991	228,877	322,826	362,407
Fabricated						
Pipe and tube	94,853	149,610	182,936	56,452	145,398	208,783
Wire	40,220	68,596	65,790	18,539	35,143	26,761
Total steel	579,492	1,172,730	842,640	355,265	589,568	663,479

Source: Statistics Canada, Trade of Canada.
Note: The values in this table relate to the tonnages shown in Table 6.

mill in Longueuil, Quebec. The Burlington Steel Division of Slater Steel Industries Limited at Hamilton, Ontario, completed a program to increase melting capacity from 254,000 to 320,000 tons a year and finishing capacity from 175,000 to 250-275,000 tons a year. At its Vancouver plant, Western Canada Steel Limited installed an 18-foot-diameter arc furnace and 36-mva transformer to raise steelmaking capacity from 110,000 to 200,000 tons a year. Melting capacity at its Calgary, Alberta plant will be doubled to 100,000 tons a year when the original melting equipment from its Vancouver plant is installed. Sydney Steel Corporation at Sydney, Nova Scotia completed installation of a bloom casting machine and modification of its No. 1 rail mill.

World review

A major reversal in total world steel demand occurred during 1975 when the market-economy countries witnessed a most serious economic recession. A balance of payments crisis and various anti-inflation measures designed to combat a high level of inflation are said to account for the decreased economic growth. As a result, unemployment reached levels not seen in previous cyclical periods since World War II. However, the situation was very different in planned-economy countries where steel production increased by 6 to 7 per cent to reflect buoyant demand and new government investment.

Preliminary figures compiled by the International Iron and Steel Institute (IISI) put world steel production

Table 8. Canada, trade in steel[1] by country, 1973-75

	Imports			Exports		
	1973	1974	1975	1973	1974	1975
	(net tons)					
United States	1,055.9	1,642.9	756.7	1,178.6	1,467.3	1,036.5
Britain	168.7	181.9	144.7	56.3	31.0	29.3
ECSC[2] countries	410.7	585.5	408.0	119.1	87.3	36.1
Japan	601.7	873.6	313.5	9.7	0.0	0.0
Other	162.7	199.5	178.9	338.3	370.2	374.5
Total	2,399.7	3,483.4	1,801.8	1,702.0	1,955.8	1,476.4

Source: Statistics Canada, *Exports and Imports by Commodities* (monthly).
[1] Comprises steel castings, ingots, semis, finished steel, forgings, pipe and wire. [2] European Coal and Steel Community (Belgium, France, Italy, West Germany, Luxembourg and Netherlands).

Table 9. Canadian crude steel supply and demand, 1960-75

	Crude Steel Production	Imports[1]		Exports[1]		Indicated Consumption[2]	
		A[3]	B[4]	A[3]	B[4]	A	B
	(000 net tons)						
1960	5,790	1,167	1,353	936	994	6,021	6,149
1961	6,466	999	1,096	803	841	6,662	6,721
1962	7,173	824	1,046	936	990	7,061	7,229
1963	8,190	789	1,295	1,274	1,369	7,705	8,116
1964	9,128	1,621	2,135	1,362	1,485	9,387	9,778
1965	10,068	2,467	2,892	1,091	1,235	11,444	11,725
1966	10,020	1,637	2,096	1,004	1,290	10,653	10,826
1967	9,701	1,523	1,981	1,196	1,368	10,028	10,314
1968	11,198	1,436	1,884	1,605	2,079	11,029	11,003
1969	10,048	2,377	2,935	1,101	1,423	11,324	11,560
1970	12,346	1,680	2,189	1,869	2,299	12,157	12,236
1971	12,170	2,503	3,136	1,789	2,130	12,884	13,176
1972	13,073	2,731	3,355	1,825	2,126	13,979	14,302
1973	14,755	2,589	3,162	1,752	2,203	15,592	15,714
1974	15,017	3,974	4,715	1,813	2,506	17,178	17,226
1975	14,357	1,888	2,419	1,281	1,894	14,964	14,882

Source: Statistics Canada.
[1] From *Trade of Canada*, adjusted to equivalent crude steel by Mineral Development Sector. [2] Production plus imports, less exports with no account taken for stocks. The two columns of figures depend on the two sets of values for trade. [3] Calculation: total finished steel (all hot and cold-rolled steel but excluding wire, steel, pipe and tube) divided by 0.77 plus steel castings, ingots and semis. See Table 6. [4] Calculation: total, hot- and cold-rolled steel, steel forgings, wire, and steel pipe and tube divided by 0.75 plus steel castings, piston ring castings, ingots, semis and ingot moulds and stools.

in 1975 at 652 million metric tons as compared to 710 million metric tons in 1974 and 697 million metric tons in 1973. This is a decrease of 58 million metric tons (-8.2 per cent) from 1974 and of 46 million metric tons (-6.5 per cent) from 1973. Details are provided in Table 10.

The U.S.S.R., with 142 million metric tons (+4.3 per cent over last year) ranks first again among steel-producing countries, followed by the United States, 105.97 million tons (-19.7 per cent); Japan, 102.21 million tons (-12.7 per cent); West Germany, 40.42 million tons (-24 per cent), the People's Republic of China, estimated at 30 million tons (+11.1 per cent); Italy, 21.85 million tons (-8.2 per cent); France, 21.52 million tons (-20.4 per cent) and the United Kingdom, 19.83 million tons (-11.5 per cent). The nine EEC countries together produced 125.32 million metric tons (-19.5 per cent).

The situation was such that some steel producers in Western Europe operated below the profit level. Activity was low in the building sector and also in the manufacturing sector. The engineering industries performed satisfactorily during a large part of the year due to longer delivery dates, but weakened during the latter part of the year.

According to the IISI, world steel exports declined by 20 million metric tons or 16 per cent. For the EEC countries, steel exports declined to 50 million metric tons in 1975, compared with 62 million tons for 1974, a decline of 20 per cent. There were lower shipments from all EEC countries except Italy. Steel exports from the United States were down 56 per cent and from Japan -12 per cent.

Prices

Steel prices in Canada continued to rise in 1975, reflecting increased costs of labour and raw materials. Late in 1974 it was believed that a continuation in the trend towards lower scrap prices would moderate steel prices in 1975. However, a major increase in labour costs in mid-year, together with a continuation in the upward trend in costs for raw materials, particularly iron ore and coking coal, made major price increases necessary. Accordingly, in August, the major steel companies posted increases ranging from 12 to 16 per cent for most products. However, the overall increase was about 10 per cent. Typical prices as of October 1 were $250 a ton for large structurals and cold-rolled sheets, $235 a ton for plate and $210 a ton for hot-rolled sheets.

With a major increase in prices of U.S. steel in October, Canadian steel held a $20 to $30 price advantage over U.S. steel. European prices, that had been about 25 per cent higher than Canadian prices in 1974, were lowered substantially during the year in accordance with the precipitous decline in demand. Some countries, faced with low domestic demand, resorted to price cutting to encourage exports. This practice led to allegations of dumping by some countries, including Canada, the U.S. and the European Economic Community (EEC), all of which react strongly to this type of market penetration.

In Western Europe, domestic steel prices weakened considerably due to cheaper imports. It was reported that temporary rebate were applied, in the order of 5-15 per cent for West Germany, 14-19 per cent for France, 14-32 per cent for the Netherlands, and 8-14 per cent for some U.K. stocks. In the United States and Canada, steel prices increased due to higher costs of production. Major producers in Canada raised their prices by 10-11 per cent. In Japan, prices declined by some 30 per cent over 1974 prices.

Export prices in the EEC for finished steel were at low levels during 1975, but by the end of the year they had recovered slightly. Steel exporters' prospects worsened during the year due to declining profit margins and increased costs of production. The supply of basic raw materials was abundant but their prices increased, particularly for iron ore, where the price increased by 40 per cent. Consumers held large stocks of iron ore by the end of the year. In scrap, attention concentrated on the better qualities, and stocks were good at the year end. Coal import prices increased due to higher production and handling costs. In 1975, the prices of steelmaking raw materials increased; for coal by 10-15 per cent; for iron ore by 40 per cent; for fuel oil by 10 per cent, and wages by 15 per cent.

Table 10. World raw steel production, 1974-75

	1974	1975
	(000 metric tons)	
U.S.S.R.	136.2	142.0
United States	132.0	106.0
Japan	117.1	102.2
West Germany	53.2	40.4
China	27.0	30.0
Italy	23.8	21.9
France	27.0	21.5
U.K.	22.4	19.8
Poland	14.6	15.1
Czechoslovakia	13.6	14.2
Canada	13.6	13.0
Belgium	16.2	11.6
Spain	11.5	11.1
Rumania	8.8	10.1
Brazil	7.5	8.4
India	7.1	8.0
Australia	7.8	7.9
South Africa	5.8	6.8
East Germany	6.2	6.5
Sweden	6.0	5.6
Mexico	5.1	5.4
Netherlands	5.8	4.8
Luxembourg	6.4	4.6
Austria	4.7	4.1
Hungary	3.5	3.7
North Korea	3.2	3.5
Yugoslavia	2.8	2.9
Bulgaria	2.2	2.3
Argentina	2.4	2.2
South Korea	1.9	1.8
Turkey	1.6	1.7
Finland	1.7	1.6
Venezuela	1.0	1.1
Taiwan	0.9	1.0
Others	9.3	9.0
Total	709.9	651.8

Source: International Iron and Steel Institute.

Canadian outlook and forecast

Growth in demand for steel in 1976 will depend largely on renewed growth in economic activity. While economic opinion predicts positive growth in 1976, the strength of the recovery will depend largely on a reasonably strong economic recovery in the United States and a minimal dampening of the Canadian economy from anti-inflation measures. Particular areas of concern in Canada and the United States for 1976 include housing, exports and consumer spending on durable goods.

Notwithstanding the positive outlook for the economy, any turnaround in steel demand will depend on increased auto production in Canada and the United States as well as increased construction activity. A definite upward trend in sales of automobiles was indicated in the U.S. and Canada in the last quarter of 1975. Prospects for a higher level of construction activity appeared good, with increases in housing starts and capital spending indicated.

Taking into account the foregoing factors, apparent steel consumption is expected to increase by 4.1 per cent to 11.4 million tons. Producer or mill shipments will be up by an estimated 4.3 per cent to 10.9 million tons as a basic reflection of increased consumption, since exports are expected to remain at the same level as in 1975. Canadian steel is expected to remain price-competitive with foreign steel and, therefore, imports will remain at the 1975 level of 1.5 million tons. Raw steel production is forecast at 15.0 million tons, up 4.5 per cent from the previous year, to exceed slightly the increase in domestic shipments.

For 1980, 1985 and 2000, crude steel consumption is forecast to be 20.8, 25.6 and 35.5 million tons, while production is expected to reach 19.1, 23.2 and 33.0

Table 11. Capital expenditures of selected Canadian companies in 1975 and plans for 1976

	Estimated for 1975	Planned for 1975	% Change
	(millions of dollars)		
Manufacturing	3,217	4,180	+30
Mining	597	931	+56
Oil and gas	1,878	2,820	+50
Oil and gas companies	488	643	+32
Transportation and storage	910	896	− 2
Communications	1,654	1,900	+15
Electric utilities	4,028	5,185	+29
Other companies	914	1,017	+11
Total	13,686	17,571	+28

Source: Department of Industry, Trade and Commerce, Ottawa.

Table 12. Canada, rolled steel supply and demand, 1972-75, forecast to 1976

	Producer or Mill Shipments[1]	Exports[2]	Imports[3]	Apparent Rolled Steel Consumption[4]	Raw Steel Production[5]
	(million net tons)				
1972	9.830	1.417	2.155	10.568	13.073
1973	10.936	1.361	2.001	11.576	14.755
1974	11.439	1.435	3.061	13.065	15.017
1975[e]	10.452	0.972	1.467	10.947	14.357
% change 1975/74	− 8.6	−32.3	−52.1	−16.2	− 4.4
1976	10.9	1.0	1.5	11.4	15.0
% change 1976/75	+ 4.3	0	0	+ 4.1	+ 4.5

Source: Statistics Canada; *Primary Iron and Steel* (monthly) and *Trade of Canada*.
[e] Estimated.
[1] Comprises domestic shipments + producer exports. A portion of domestic shipments to warehouses and steel service centres is also exported. Excludes steel castings amounting to 174,000 tons in 1972, 192,000 tons in 1973, 208,000 tons in 1974 and 215,000 tons in 1975. [2] Total exports includes producer exports plus exports from warehouses and steel service centres. Excludes exports of pipe, wire, forgings and steel castings. [3] Excludes imports of pipe, wire, forgings and steel castings. [4] Excludes apparent consumption of steel castings. [5] Includes production of steel castings amounting to 181,067 tons in 1972, 206,159 tons in 1973, 221,838 tons in 1974 and 239,312 tons in 1975.

million tons respectively. See Table 13. These forecasts were based on forces already at work and assumed that no fundamental changes in current trends would occur.

While both exports and imports of rolled steel are expected to increase over, this period of time, the trade imbalance will reflect higher imports, with the difference amounting to 0.8, 1.4 and 1.9 million tons in 1975, 1980 and 1985, respectively. It seems certain that Canadian exports will be constrained by political decisions in importing countries (mainly the United States) and while it is expected that producer shipments will remain as forecast, this will mean there must be a transfer of potential exports to domestic shipments, thereby reducing import requirements.

Trends in steel processing could profoundly influence future raw material requirements, as different processes require widely divergent proportions of raw materials, including different quantities and types of energy inputs. Open-hearth furnaces and basis oxygen furnaces (BOF) can use different proportions of steel scrap and pig iron (hot metal), whereas electric steelmaking uses only scrap and more recently, reduced iron.

Table 13. Canada, forecast of rolled and crude steel supply and demand, 1980, 1985 and 2000

	1980	1985	2000	
			Low	High
	(000 net tons)			
A. Rolled Steel, and Semis and Ingots				
Total producer shipments	14,632	17,784	25,300	28,671
Apparent consumption	15,934	19,678	27,200	32,968
B. Raw Steel Equivalents[1]				
Total producer shipments	18,867	22,961	32,722	37,100
Apparent consumption	20,543	25,406	35,175	42,665
C. Steel Castings				
Total producer shipments	228	252	322	322
Apparent consumption	216	240	310	310
D. Total Raw Steel (B + C)				
Total producer shipments	19,095	23,213	33,044	37,422
Apparent consumption	20,756	25,646	35,485	42,975
Net increase in imports[2]	1,661	2,433	2,441	5,553

1 (Rolled steel + semis and ingots) less (total semis and ingots) x 0.77 (i.e. one ton of raw steel is equivalent to 0.77 tons of rolled steel) plus (total semis and ingots). 2 Imports currently in excess of exports promises to increase because of higher growth for consumption compared with production.

Table 14, Canada, forecast of raw material requirements for steelmaking, 1980, 1985 and 2000

	Steel Production Forecast	Scrap Requirements	Source of Scrap			Pig Iron	Coking Coal	Iron Ore
				Shortfall				
			Home Scrap	Reduced Iron[3]	Purchased Scrap			
			(000 net tons)					
Electric Steel								
1980	4,800	5,472[1]	1,368[2]	1,600	2,504	—	—	2,165[4]
1985	5,800	6,612[1]	1,653[2]	2,600	2,359	—	—	3,517[4]
2000	8,300	9,462[1]	2,366[2]	3,790	3,306	—	—	5,128[4]
BOF Steel								
1980	11,295	3,614[5]	2,823[6]	—	791	9,600[7]	7,680[8]	14,688[9]
1985	17,413	5,572[5]	4,004[6]	—	1,568	14,801[7]	11,841[8]	22,645[9]
2000	24,744	7,918[5]	5,196[6]	—	2,722	21,032[7]	16,825[8]	32,179[9]
Open Hearth Steel								
1980	3,000	1,200[10]	870[6]	—	330	2,130[11]	1,704[8]	3,259[9]
1985	—	—	—	—	—	—	—	—
2000	—	—	—	—	—	—	—	—
TOTAL								
1980	19,095	10,286	5,061	1,600	3,625	11,730	9,384	20,112
1985	23,213	12,184	5,657	2,600	3,927	14,801	11,841	26,162
2000	33,044	17,380	7,562	3,790	6,028	21,032	16,825	37,307

Source: Goodman, R.J. and Lafleur, P. *Future Raw Material Needs of the Canadian Steel Industry,* 78th Annual General Meeting of the Canadian Institute of Mining and Metallurgy, Quebec City, April 1976.
1 Calculated by applying a factor of 1.14 to steel production. 2 Calculated by applying a factor of 25% to total scrap demand. 3 In terms of scrap equivalents (1 ton reduced iron = 1.07 tons scrap). 4 It takes approximately 1.353 tons of iron ore to make 1 ton of reduced iron. 5 Some 32% of steel production. 6 Home scrap, currently produced at a rate of 29% of steel production, will be reduced appreciably by widespread introduction of continuous casting. The ratio is estimated at 25% for 1980, 23% for 1985 and 21% for 2000. 7 Some 85% of steel production. 8 Calculated using a ratio of coal consumed in coke ovens to pig iron production of 0.80. 9 Calculated using ratio of 1.53 net tons of iron ore to one ton of pig iron. 10 Some 40% of steel production. 11 Some 71% of steel production.

Table 15. Forecast iron castings production and raw material requirements, 1980, 1985 and 2000

	Iron Castings Production	Scrap Total[1]	Scrap Home[2]	Scrap Purchased	Pig Iron[3] (Basic)	Coking Coal[4]	Iron Ore[5]
			(000 net tons)				
1980	1,338	1,442	542	900	377 (297)	302	454
1985	1,494	1,610	605	1,005	421 (341)	337	521
2000	1,962	2,115	795	1,320	553 (473)	442	723

Source: Goodman, R.J. and Lafleur, P., *Future Raw Material Needs of the Canadian Steel Industry,* 78th Annual General Meeting of the Canadian Institute of Mining and Metallurgy, Quebec City, April, 1976.

[1] Some 29.3% of total iron units. [2] Some 37.6% of total scrap requirements. [3] An estimated 80,000 tons a year will be supplied from "remelt" iron produced as a byproduct of ilmenite smelting. [4]Calculated using a ratio of coal consumed in coke ovens to pig iron production of 0.80. [5]Calculated using ratio 1.53 net tons of iron ore to one ton of pig iron.

Certain assumptions have to be made in order to predict production by steelmaking method. Open-hearth steelmaking is expected to be phased out to reflect the application of better process economies, though the exact timing of this phase-out is unknown. Accordingly, open-hearth capacity currently at 4.13 million tons a year is assumed to be replaced by either BOF or electric steelmaking capacity between 1980 and 1985.

Electric steelmaking, on the other hand, will probably experience accelerated growth based on the following factors: increased federal and provincial support for regional electric steelmaking plants, the technical and economic success of direct reduction processes as a supplementary supply of iron units in scrap-deficient localities, the availability of suitable high quality feed for the making of reduced iron, the continued availability of reasonably-priced power, electric steelmaking plants achieving better scale-up economies, the feasibility of electric steel plant diversification into products other than bars, using reduced iron low in residuals; the ability to expand in terms of small increments to match market growth, and the lower unit capital cost of electric steelmaking facilities in comparison with integrated plants.

Linear analysis of previous trends does not fully reflect the strong growth in electric steel production expected to 1980. Expansions expected over the next five years suggest that 4.8 million tons may be a reasonable level of production. Due to local market saturation, and other factors, this accelerated growth may moderate thereafter to parallel steel growth in general, which is forecast at 3.7 per cent annually from 1980 to 2000. Electric steel production is therefore forecast at 4.8 million tons in 1980, 5.8 million tons in 1985 and 8.3 million tons in 2000.

As Table 14 indicates, BOF production is taken as the difference in total production and production by the other methods.

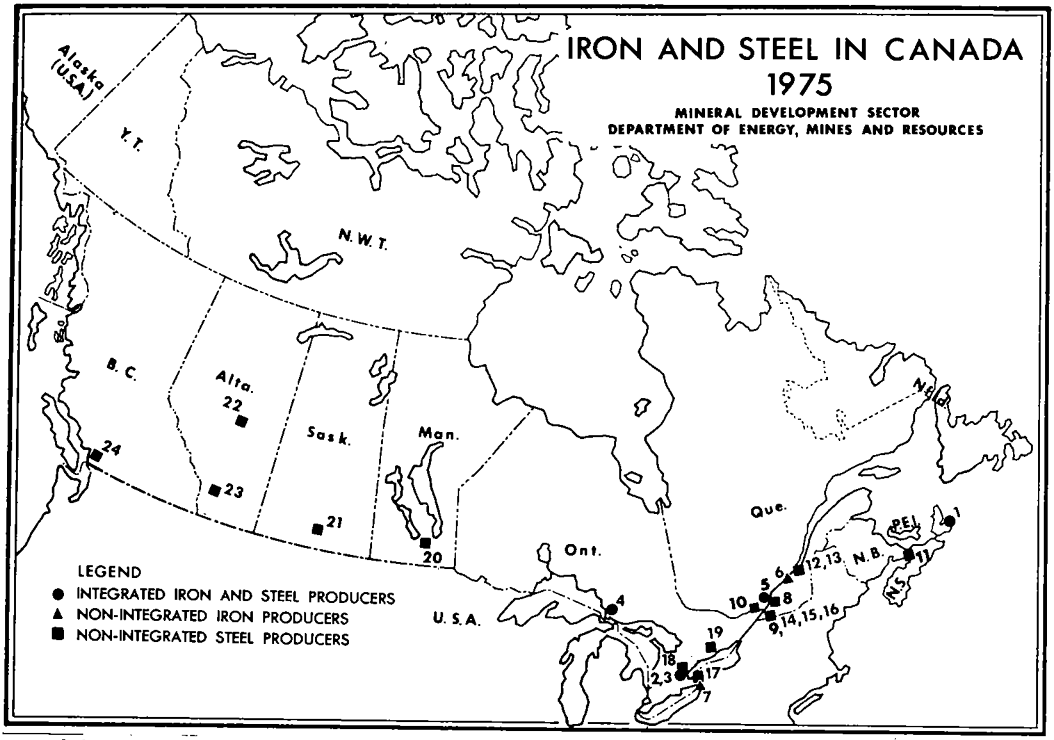
Raw material requirements for steelmaking and cast iron production are outlined in Tables 14 and 15 and summarized in Table 16. This forecast is essentially a projection of current and most probable trends which take into account a synthesis of the major factors that could affect steel production. Despite the attractiveness of many new processes being currently introduced, they will have initially only a marginal effect on the steel industry as a whole since the large amounts of capital needed for steelmaking ties the producer to existing technology for some time.

Table 16. Summary table of raw material requirements for iron castings and steel production, 1980, 1985 and 2000

	Scrap Total	Scrap Home	Scrap Reduced Iron[1]	Scrap Purchased	Coking Coal[2]	Iron Ore
			(000 net tons)			
1980	11,728	5,603	1,600	4,525	9,986	20,566
1985	13,794	6,262	2,600	4,932	12,478	26,683
2000	19,495	8,357	3,790	7,348	17,567	38,030

Source: Goodman, R.J. and Lafleur, P., *Future Raw Material Needs of the Canadian Steel Industry,* 78th Annual General Meeting of the Canadian Institute of Mining and Metallurgy, Quebec City, April 1976.

[1] In terms of scrap equivalents (1 ton scrap iron = 1.07 tons reduced iron). [2] Including 300,000 tons a year for the production of "remelt" iron.



Integrated iron and steel producers (numbers refer to numbers on map)

1. Sydney Steel Corporation (Sydney)
2. Dominion Foundries and Steel, Limited (Hamilton)
3. The Steel Company of Canada, Limited (Hamilton)
4. The Algoma Steel Corporation, Limited (Sault Ste. Marie)
5. Sidbec-Dosco Limited (Contrecoeur)*

Nonintegrated iron producers

6. Quebec Iron and Titanium Corporation (Sorel)
7. Canadian Furnace Division of Algoma (Port Colborne)

Principal nonintegrated steel producers

8. The Steel Company of Canada, Limited (Contrecoeur)
9. QSP Ltd. (Montreal)
10. Ivaco Industries Limited (L'Orignal, Ontario)
11. Enheat Limited (Amherst)
12. Atlas Steels Division of Rio Algom Limited (Tracy)
13. Colt Industries (Canada) Ltd. (Sorel)
14. Canadian Steel Foundries Division of Hawker Siddeley Canada Ltd. (Montreal)
15. Canadian Steel Wheel Limited (Montreal)
16. Sidbec-Dosco Limited (Montreal)
17. Atlas Steels (Welland)
18. Burlington Steel Division of Slater Steel Industries Limited (Hamilton)
19. Lake Ontario Steel Company Limited (Whitby)
20. Manitoba Rolling Mills Division of Dominion Bridge Company, Limited (Selkirk)
21. Interprovincial Steel and Pipe Corporation Ltd. (Regina)
22. Premier Works of Stelco (Edmonton)
23. Western Canada Steel Limited (Calgary)
24. Western Canada Steel Limited (Vancouver)

* Iron ore reduction facilities installed in 1973.

Lead

G.R. PEELING

In 1975 Canada's production of lead, based on lead produced from domestic materials and the recoverable content of ores and concentrates exported, was estimated at 373,065 tons*, an increase of 15.0 per cent over the strike-reduced level of 1974. The value of production also increased 13.0 per cent to $151.8 million, although metal prices declined from the 1974 level. The total mine output of lead, expressed as the lead content of domestic ores and concentrates produced, was estimated at 375,758 tons compared with 332,195 tons in 1974.

Primary refined lead output totalled 189,064 tons in 1975, an increase of 35.6 per cent from 1974. The 1974 production level was abnormally low because of an extended labour strike at Cominco Ltd.'s refinery at Trail, British Columbia. The lead smelter and refinery complex of Cominco Ltd. at Trail has an installed capacity level of 210,000 tons annual production but because of operating difficulties associated with lead-in-air emissions in the smelter, the effective capacity has been reduced to the 170,000-ton level. The only other producer of primary refined lead in Canada is the Brunswick Mining and Smelting Corporation Limited which has a refinery of 79,400 tons annual capacity at Belledune, New Brunswick.

About 40 per cent of the lead ores and concentrates produced in western and northern Canada were treated in Japan, about 31 per cent in Canada, about 20 per cent in Europe, and 5 per cent and 4 per cent, respectively, in the United States and South America. In eastern Canada, about 67 per cent of ore and concentrates produced were treated in Canada, 17 per cent in the United States and 16 per cent in Europe.

Exports of lead contained in ores and concentrates increased to 233,589 tons in 1975 from 213,946 tons in 1974. The major portion of these exports, 133,152 tons (57 per cent) was shipped to Japan. Most of the remainder was shipped to smelters in the United States, West Germany, Brazil and Belgium and Luxembourg. Metal exports in 1975 were 121,195 tons, a substantial increase from the 80,924 tons in 1974. Britain and the United States, combined, continued to be the major customers, accounting for 61 per cent of the total. Imports of refined metal were 3,786 tons in 1975 compared with 19,194 tons in 1974.

Canadian consumption of primary and secondary lead metal in 1975 was 59,977 tons and 38,341 tons, respectively, compared to 71,875 tons and 38,221 tons respectively in 1974.

Canadian developments

Canadian lead production in 1975 was affected adversely by the worldwide recession which caused a serious decline in demand for all metals. Although Canadian producers were not forced to take action against worsening market conditions in late 1974 because output had already been reduced by prolonged labour strikes, restraint in the form of stockpiling, production slowdowns and extended shutdowns became necessary in 1975. Although 1975 mine and metal production of lead in Canada was significantly above the 1974 levels, production was still substantially below the 1973 levels. Two lead-producing mines closed during 1975 because of exhausted reserves: Reeves MacDonald Mines Limited — Annex mine; and Clinton Copper Mines Ltd. — Clinton mine. No new mines came into production in 1975 but Consolidated Columbia River Mines Ltd. re-opened its Ruth Vermont mine near Golden, British Columbia. A snowslide in 1973 had destroyed the mill.

Mine production

Newfoundland. ASARCO Inc. (formerly American Smelting and Refining Company) operates the Buchans mine in central Newfoundland, the only lead producer in the province. Output of lead concentrates in 1975 was 20,247 tons, a drop of 3,712 tons from 1974. Lower throughput in the mill and the treatment of lower-grade ore were the main reasons for reduced production in 1975. Ore reserves at year-end were 1.1 million tons grading about 12 per cent zinc, 7 per cent lead, 1 per cent copper, 0.02 ounce gold and 3.0 ounces silver a ton, sufficient to maintain present operating levels for about five years.

* The short ton of 2,000 pounds is used throughout unless otherwise stated.

Nova Scotia. There were no mine producers of lead in this province, but exploration and development work continued on the Gays River property of Cuvier Mines Ltd. Imperial Oil Limited has a 60 per cent interest in the property and Cuvier Mines a 40 per cent interest. Cuvier announced that Preussag Canada Limited will supply up to $7.0 million in development financing if the project goes to the production stage, assume Cuvier's obligations to Imperial Oil with respect to past expenditures and finance Cuvier's share of the present underground exploration program. In return, Preussag will receive an indirect 16.09 per cent interest in the joint venture and have first right of refusal on purchase of 40 per cent of concentrate output should the venture go to the production stage. A $1.5 million underground development program was initiated in 1975 involving the construction of a 2,200-foot decline into the flat-lying ore zone. Construction of the decline had progressed 850 feet by early 1976.

New Brunswick. The mine operations of Brunswick Mining and Smelting Corporation Limited returned to normal in 1975 after strikes had reduced the level of output in 1974. The No. 6 and No. 12 mines produced 59,689 tons of lead in concentrates in 1975 compared with 45,623 tons in 1974. Ore reserves at the two mines increased at year-end 1975 to 100.8 million tons grading 9.1 per cent zinc, 3.7 per cent lead, 0.3 per cent

Table 1. Canada, lead production, trade and consumption 1974-75.

	1974		1975p	
	(Short tons)	($)	(Short tons)	($)
Production				
All forms[1]				
Yukon	99,475	41,194,600	138,234	56,260,000
British Columbia	60,905	25,222,386	76,447	31,114,000
Northwest Territories	84,355	34,932,761	75,777	30,841,000
New Brunswick	52,723	21,833,300	62,264	25,341,000
Newfoundland	15,490	6,414,818	11,176	4,549,000
Ontario	10,110	4,187,081	7,426	3,023,000
Quebec	1,056	437,403	1,597	650,000
Manitoba	44	18,078	144	59,000
Nova Scotia	216	89,680	–	–
Total	324,374	134,330,107	373,065	151,837,000
Mine output[2]	332,195		375,758	
Refined production[3]	139,380		189,064	
Exports				
Lead contained in ores and concentrates				
Japan	124,376	39,804,000	133,152	32,348,000
United States	27,366	5,693,000	42,292	9,729,000
West Germany	20,534	4,244,000	26,317	4,963,000
Brazil	11,890	3,552,000	17,393	3,821,000
Belgium and Luxembourg	5,156	1,787,000	9,495	1,893,000
Italy	4,466	924,000	2,496	403,000
United Kingdom	10,639	2,751,000	2,444	486,000
Other	9,519	2,633,000	–	–
Total	213,946	61,388,000	233,589	53,643,000
Lead, pigs, blocks and shots				
United Kingdom	32,525	15,359,000	48,839	17,751,000
United States	30,802	11,928,000	25,543	11,051,000
People's Republic of China	–	–	15,981	5,901,000
Italy	4,061	1,141,000	7,663	3,103,000
West Germany	552	254,000	4,977	1,572,000
United Arab Republic	–	–	4,539	1,632,000
Netherlands	2,130	1,077,000	2,991	941,000

Table 1. (cont'd)

	1974		1975ᵖ	
	(short tons)	($)	(short tons)	($)
Exports (cont'd)				
Lead, pigs, blocks and shots (cont'd)				
Switzerland	—	—	2,569	713,000
India	3,778	1,692,000	2,338	878,000
Pakistan	2,855	939,000	2,019	771,000
Other	4,221	1,384,000	3,736	1,308,000
Total	80,924	33,774,000	121,195	45,621,000
Lead and alloy scrap (gross weight)				
South Africa	336	108,000	3,974	607,000
Brazil	881	165,000	3,282	471,000
United States	933	274,000	1,863	349,000
Turkey	—	—	1,102	243,000
Venezuela	293	60,000	851	134,000
Netherlands	3,207	1,335,000	614	137,000
South Korea	1,468	212,000	272	40,000
Denmark	278	159,000	256	112,000
Other	3,048	865,000	860	310,000
Total	10,444	3,178,000	13,074	2,403,000
Lead fabricated materials not elsewhere specified				
United States	8,946	5,215,000	6,179	3,691,000
United Kingdom	60	20,000	269	120,000
West Germany	—	—	77	2,000
Peru	—	—	50	3,000
Other	1,078	1,228,000	90	78,000
Total	10,084	6,463,000	6,665	3,894,000
Imports				
Lead pigs, blocks and shot	12,519	6,169,000	2,163	925,000
Lead oxide; litharge, red lead, mineral orange	5,856	3,297,000	1,104	650,000
Lead fabricated materials not elsewhere specified	774	647,000	519	574,000
Total	19,149	10,113,000	3,786	2,149,000

Table 1. (concl'd)

	1974			1975p		
	Primary	Secondary[4]	Total	Primary	Secondary[4]	Total
Consumption	(short tons)					
Lead used for, or in the production of,						
antimonial lead	1,295	15,187	16,482	1,213	13,494	14,707
battery and battery oxides	28,888	5,417	34,305	20,842	2,006	22,848
cable covering.	3,126	646	3,772	3,650	590	4,240
chemical uses; white lead, red lead, litharge, tetraethyl lead, etc.	23,022	**	23,022	21,153	**	21,153
copper alloys; brass, bronze, etc.	418	90	508	164	62	226
lead alloys						
solders	4,755	3,943	8,698	2,423	5,597	8,020
others (including babbitt, type metals, etc.)	1,564	6,090	7,654	1,238	1,739	2,977
semifinished products: pipe, sheet, traps, bends, blocks for caulking, ammunition, foil, collapsible tubes, etc.	5,383	362	5,745	4,716	891	5,607
Other	3,424	6,486	9,910	4,578	13,962	18,540
Total, all categories	71,875	38,221	110,096	59,977	38,341	98,318

Source: Statistics Canada.
[1]Lead content of base bullion produced from domestic primary materials (concentrates, slags, residues, etc.) plus estimated recoverable lead in domestic ores and concentrates reported. [2]Lead content of domestic ores and concentrates exported. [3]Primary refined lead from all sources. [4]Includes all remelt scrap lead and scrap lead used to make antimonial lead.
pPreliminary; — Nil; . . Not available; **Included in Other.

copper and 2.8 ounces of silver a ton, on a weighted average basis; up 8.4 million tons from year-end 1974. The 48-million-dollar expansion program at the No. 12 underground mine continued on schedule. Progress on the new 4,500-foot shaft, to be completed by 1977, included excavation to the final 26-foot-diameter size to 471 feet below surface, the pouring of concrete to 427 feet below the collar, and shaft steel installed to a depth of 227 feet. Hoisting capacity when the program is complete will be 11,000 tons a day and should raise lead in concentrate capacity from about 60,000 tons in 1975 to some 70,000 tons in 1981 (based on present grade and recoveries).

Production of lead in concentrates at Heath Steele Mines Limited at Newcastle decreased about 14 per cent in 1975 because of processing of lower-grade ore. Work on the new No. 5 shaft had progressed to a depth of 2,935 feet by the end of the year, with completion to a depth of 3,250 feet scheduled for mid-1976. Production at a rate of 4,000 tons a day should be achieved by late 1976 (present operations are at 3,100 tons a day). Ore reserves at year-end were 35.2 million tons grading 4.4 per cent zinc, 1.57 per cent lead, 1.18 per cent copper and 1.74 ounces of silver a ton.

Nigadoo River Mines Limited completed its first full year of operation in 1975 since resuming production early in 1974 at its Bathurst area zinc-lead-copper-silver property. Consequently, production of lead in concentrates increased 29 per cent in 1975 to 5,688 tons compared with 4,406 tons in 1974. Ore reserves in the A and C zones at year-end are reported as 0.7 million tons grading 3.15 per cent zinc, 3.14 per cent lead, 2.30 per cent copper, and 3.98 ounces of silver a ton. Reserves in the Anthonian zone, discovered in 1974, are given as 0.3 million tons grading 4.22 per cent zinc, 3.91 per cent lead, 0.16 per cent copper and 3.69 ounces of silver a ton. Since this zone is located a considerable distance from the main mine, market conditions will have to be excellent to justify production from the Anthonian in the future.

New Brunswick, particularly the Bathurst area, was one of the most active sites for exploration and development work in all Canada. The Nine Mile Brook area in the Bathurst region was the location for several new finds. Texasgulf Inc. is considering a 2,800-foot exploratory shaft for its Half Mile Lake zinc-lead-copper-property in this region. The ore zone has an estimated 6.8 million tons grading 6.5 per cent zinc, and 2.5 per cent lead, with another zone containing 1.0 million tons grading 2.0 per cent copper. The latter zone extends into the adjoining Bay Copper Mines Limited property (which is owned 79 per cent by Conwest Exploration Company Limited).

Quebec. There was only a small amount of lead produced in Quebec in 1975, mostly as a byproduct from copper-zinc and zinc producers. Operations ceased in mid-year at the mine of Clinton Copper Mines Ltd. because of depleted reserves.

Lead in concentrate production from the Val d'Or property of Manitou-Barvue Mines Limited declined to 443 tons because of lower recovery in the mill and the treatment of lower-grade ore. Ore reserves at year-end were 0.9 million tons grading 2.16 per cent zinc, 0.36 per cent lead, 0.02 ounce of gold and 3.72 ounces of silver a ton.

The Sullivan Mining Group Ltd. reported a decline in lead in concentrate production during 1975. The Cupra Division, which also custom-mills ore for the wholly-owned subsidiary D'Estrie Mining Company Ltd. and the 38.7 per cent-owned Clinton Copper Mines Ltd., had a 16 per cent drop in production of lead because of lower ore grades treated and lower recovery in the mill. Ore reserves at Cupra are 46,800 tons grading 3.63 per cent zinc, 2.66 per cent copper, 0.51 per cent lead, 0.014 ounce gold and 1.02 ounces of silver a ton. Reserves at D'Estrie are reported as 0.9 million tons grading 1.52 per cent zinc, 2.78 per cent copper, 0.56 per cent lead, 0.015 ounce gold and 1.11 ounces of silver a ton.

Ontario. Mine production of lead in Ontario decreased by about 30 per cent in 1975 as producers adjusted production rates to coincide with market conditions.

Mine production of lead at the Kidd Creek mine of Texasgulf Canada Ltd. (formerly Ecstall Mining Limited), a subsidiary of Texasgulf Inc., was down marginally from 1974 production. Ore milled in 1975 declined only from 3.7 to 3.6 million tons but the grade of ore extracted dropped from 0.30 per cent lead to 0.25 per cent, resulting in 4,051 tons of lead in concentrate produced in 1975 compared to 4,198 tons in 1974. Ore reserves were reported at year-end to be 92 million tons above the 2,800-foot level, grading 5.92 per cent zinc, 2.7 per cent copper, 0.21 per cent lead, and 2.31 ounces of silver a ton. There is an additional 6 million tons of inferred ore above the 2,800-foot level and diamond drilling below this level intersected ore to at least 5,000 feet, with the ultimate depth and dimension of the ore body still unknown. The expansion program to increase production from 3.6 to 5 million tons of ore a year by the addition of the No. 2 underground mine and installation of a fourth circuit in the concentrator is on schedule. With the new mill circuit scheduled for start-up in late 1978, the mill capacity will be 13,500 tons a day compared to the present 10,000 tons a day. The six-foot pilot borehole for the No. 2 shaft is now completed to the 2,800-foot level, while enlargement of this hole and lining with concrete to the finished inside diameter of 25 feet has progressed to the 2,600-foot level. The expansion program is expected to cost $100 million by

Table 2. Canada, lead production, trade and consumption, 1965-75

	Production		Exports				
	All Forms[1]	Refined[2]	In Ores and Concentrates	Refined	Total	Imports Refined[3]	Consumption[4]
				(short tons)			
1965	291,807	186,484	106,964	129,065	236,029	71	90,168
1966	300,622	184,871	112,934	106,468	219,402	626	96,683
1967	317,963	193,235	126,194	132,230	258,514	438	93,953
1968	340,176	202,100	143,853	138,781	282,634	152	94,660
1969	318,632	187,143	140,175	107,090	247,265	131	105,915
1970	389,185	204,630	165,912	152,821	318,733	2,199	93,437
1971	405,510	185,554	214,354	136,884	351,238	4,632	92,961
1972	369,425	205,978	178,576	140,841	319,417	11,520	116,234
1973	376,939	206,012	222,407	125,281	347,688	4,011	119,434
1974	324,374	139,380	213,946	80,924	294,870	12,519	110,096
1975[p]	373,065	189,064	233,589	121,195	354,784	2,163	98,318

Source: Statistics Canada.
[1]Lead content of base bullion produced from domestic primary materials (concentrates, slags, residues, etc.) plus the estimated recoverable lead in domestic ores and concentrates exported. [2]Primary refined lead from all sources. [3]Lead in pigs and blocks. [4]Consumption of lead; primary and secondary in origin.
[p]Preliminary;

completion in late 1978 or early 1979. In other developments, Texasgulf is continuing its investigation into hydrometallurgical treatment of the high silver-lead concentrates. A pilot plant began operations in late 1975 and initial results are encouraging. A feasibility study is now being prepared for a 200-ton-a-day hydrometallurgical plant to treat the silver-lead concentrates plus the lead residues from the zinc plant and the flue dust from the copper plant, which should come into production by the end of the expansion program.

Output of lead from Mattabi Mines Limited at Sturgeon Lake was cut in half as the company milled a lower tonnage of lower-grade ore. Another reason for the sharp decrease in lead output was that as a result of poor markets, the company treated stockpiled ore of low grade, and because of oxidization, lead recovery was only in the order of 26.5 per cent. Mattabi is preparing to switch from open-pit to underground mining by 1979 and to a lower rate of milling at about 2,000 tons a day. A 3,500-foot access decline to the planned main haulage level was completed in 1975. Underground work on the location of the crusher and conveyor system will continue in the spring of 1976. Ore reserves were reported as 9.9 million tons grading 6.70 per cent zinc, 0.74 per cent copper, 0.70 per cent lead and 2.62 ounces of silver a ton.

The Geco Division of Noranda Mines Limited at Manitouwadge reduced production 10 per cent in June, and in addition, milling operations were suspended for two weeks in August to reduce zinc output. As a result of the lower tonnage milled and reduced recoveries of lead, output of lead in concentrates fell off to 908 tons in 1975 compared to 1,731 tons in 1974. The major capital expenditure in 1975 was for the installation of the second phase of waste-water treatment for environmental protection and control. The program also included the construction of a reactor clarifier system. Ore reserves at year-end were 28.1 million tons grading 3.62 per cent zinc, 1.87 per cent copper, 0.20 per cent lead and 1.52 ounces of silver a ton.

Willroy Mines Limited, also with operations at Manitouwadge, showed a small decline in lead in concentrate production to 439 tons from 550 tons in 1974. The company had lower mill throughput and mined lower-grade ore in 1975. Reserves are reported as 0.6 million tons grading 3.91 per cent zinc, 0.47 per cent copper, 0.16 per cent lead and 1.54 ounces of silver a ton. Reserves, which were extended in 1975 by the development of the No. 1 zone on the 550-foot level at the Willecho shaft, are sufficient for two more years of operation at present production rates.

The Sturgeon Lake Joint Venture operated by Falconbridge Copper Limited opened officially in February 1975 after several months of start-up problems in late 1974. In an effort to solve poor recoveries in the mill, about $850,000 was spent in 1975 on expanding the mill from 800 to 1,200 tons a day. Further work in the mill is slated for 1976 at a cost of $350,000. In 1975, 376,682 tons of ore were treated in the mill, resulting in production of 279 tons of lead in concentrate. Recoveries are still very low for lead and the concentrate itself only grades 7.78 per cent lead. Ore reserves at the end of 1975 were 1.8 million tons grading 10.19 per cent zinc, 2.8 per cent copper, 1.42 per cent lead, 5.82 ounces of silver and 0.021 ounce of gold a ton. The capital cost of bringing this property to the production stage was $18.3 million. Falconbridge Copper, as the operator, has a 13.4 per cent interest; NBU Mines Limited a 6.6 per cent interest and Sturgeon Lake Mines Limited an 80 per cent interest, which only becomes effective once the development costs have been recovered. The last named company is 67 per cent owned by Falconbridge Copper and 33 per cent by NBU.

Development at the Lyon Lake Division of Mattagami Lake Mines Limited, near Ignace, Ontario, continued as shaft sinking advanced to the 688-foot level, with three level stations cut. Surface plant construction is now completed. Work planned for 1976 includes completion of shaft sinking and ore passages, and the beginning of underground lateral developments. Initial production of 1,000 tons a day is planned for late 1977 or early 1978 when spare capacity will be available at the neighbouring concentrator at Mattabi Mines Limited which is 60 per cent owned by Mattagami Lake Mines Limited. Ore reserves at the Lyon Lake property are 4.0 million tons grading 6.66 per cent zinc, 1.15 per cent copper, 0.63 per cent lead, 3.30 ounces of silver and 0.01 ounce of gold a ton.

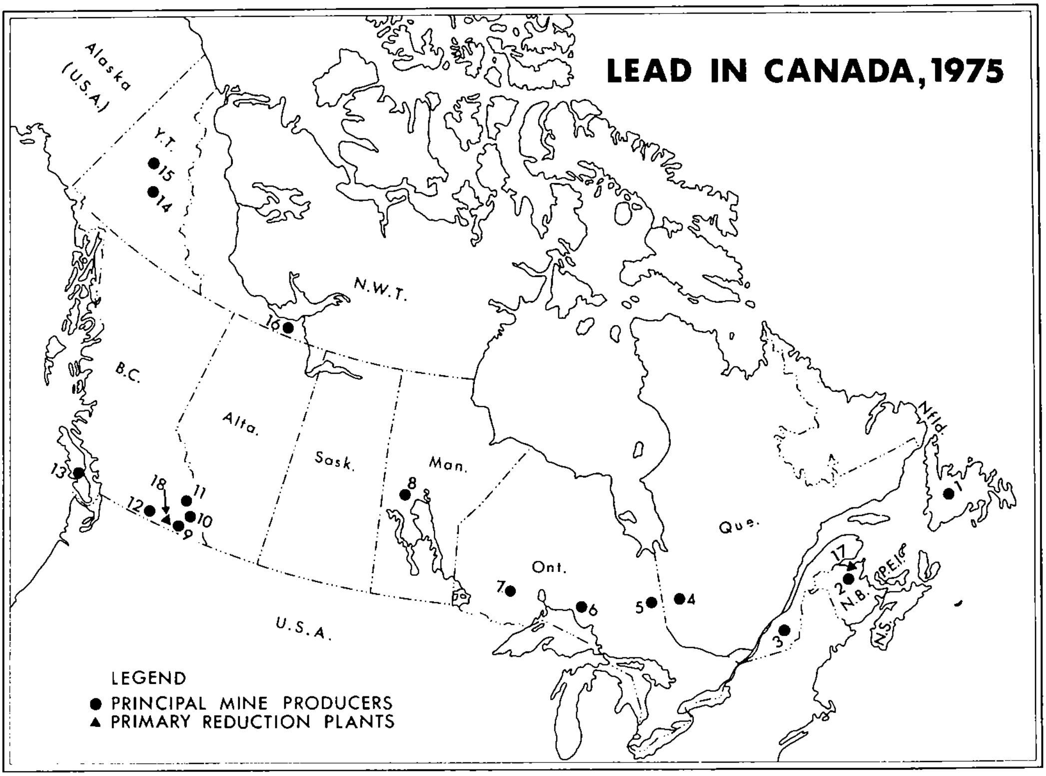
Manitoba and Saskatchewan. A small amount of lead was produced from the mining operations of Hudson Bay Mining and Smelting Co., Limited. Hudson Bay operated nine mines in the Flin Flon — Snow Lake area in 1975. Lead production was about 160 tons compared with 47 tons in 1974. Reserves from the group at the end of 1975 were 17.5 million tons grading 2.8 per cent zinc, 2.77 per cent copper, 0.2 per cent lead, 0.033 ounce of gold and 0.52 ounce of silver a ton.

British Columbia. The Sullivan and H.B. mines of Cominco Ltd. returned to normal production in 1975 after a four-month strike severely restricted output in 1974. Lead in concentrate production in 1975 increased to 71,248 tons at Sullivan but dropped to 1,628 tons at the H.B. mine. The 1974 figures were 51,837 and 2,235 tons respectively. The lower output at the H.B. mine resulted from the treatment of low-grade ore (0.56 per cent lead in 1975 compared to 1.1 per cent in 1974). Recoveries were also lower in the mill during 1975. The Sullivan mine is undergoing a $4 million program to convert from slusher mining to predominantly trackless drawpoint methods. The program is also designed to improve efficiency and control hot ore caused by oxidation. Ore reserves for the two mines are listed as 59 million tons grading 10.8 per cent combined lead-zinc.

The Ruth Vermont mine near Golden, owned by Consolidated Columbia River Mines Ltd., reopened in

October 1975 after being shut down in January 1974 when a snow slide destroyed the mill. The mine operated till November 1975 and milled 11,308 tons of ore to produce 208 tons of lead in concentrate. The mine will commence permanent operations in March 1976 at a rate of 500 tons a day. Year-end ore reserves were 0.3 million tons proven and 1.1 million tons probable and inferred grading 5.53 per cent zinc, 5.03 per cent lead and 5.95 ounces of silver a ton.

Output of lead in concentrates from the Silmonac mine of Kam-Kotia Mines Limited increased to 652 tons in 1975 compared with 397 tons in 1974. Although the tonnage milled did not increase, the grade of lead in the ore treated increased from 3.28 per cent in 1974



Principal mine producers
(numbers refer to numbers on map)

1. ASARCO Incorporated
   (Buchans Unit)
2. Brunswick Mining and Smelting Corporation Limited (Nos. 12 and 6 mines)
   Heath Steele Mines Limited
   Nigadoo River Mines Limited
3. Sullivan Mining Group Ltd. Cupra Division
   D'Estrie Mining Company Ltd.
4. Manitou-Barvue Mines Limited
5. Texasgulf Canada Ltd.
6. Noranda Mines Limited, Geco Division
   Willroy Mines Limited
7. Mattabi Mines Limited
   Sturgeon Lake Mines Limited
8. Hudson Bay Mining and Smelting Co., Limited (Chisel Lake, Ghost Lake mines)
9. Reeves MacDonald Mines Limited (Annex mine)
10. Cominco Ltd. (Sullivan and H.B. mines)
11. Kam-Kotia Mines Limited (Silmonac mine)
12. Teck Corporation Limited (Beaverdell mine)
13. Western Mines Limited
14. Cyprus Anvil Mining Corporation
15. United Keno Hill Mines Limited
16. Pine Point Mines Limited

Primary reduction plants

17. Brunswick Mining and Smelting Corporation Limited, Smelting Division
18. Cominco Ltd.

to 5.66 per cent in 1975. Reserves were reported to be 10,000 tons of probable ore at year-end.

The Annex mine, owned by Reeves MacDonald Mines Limited, ceased operations on March 31, 1975 due to depleted ore reserves. The mine produced 167 tons of lead in concentrates during the three months prior to closure.

Operations at Teck Corporation Limited's Beaverdell mine were normal during 1975 and output of lead was at the same level as 1974. Reserves are not reported. Routine property development is planned for 1976 and output is expected to be at the same level as in 1975.

Production at the Lynx and Myra Falls mines of Western Mines Limited on Vancouver Island was slightly below the 1974 level. Lead in concentrate production dropped from 4,060 tons to 3,813 tons in 1975, mainly as the result of treating lower-grade ore. Reserves reported by Western Mines at year-end are 1.7 million tons grading 7.9 per cent zinc, 1.2 per cent copper, 1.2 per cent lead, 0.09 ounce of gold and 4.20 ounces of silver a ton.

Northair Mines Ltd. continued underground exploration and development work as well as mill construction at its Brandywine Falls silver-gold-lead-zinc property about 70 miles north of Vancouver. Plans are to bring the property into production in early 1976 at a mining rate of 300 tons a day. The property is a multi-vein deposit with the more important ore zones being the Warman, Manifold and Discovery veins. Total reserves have been estimated at 459,200 tons grading 3.2 ounces of silver, 0.46 ounce of gold, 2.28 per cent lead and 3.09 per cent zinc a ton.

Yukon Territory. The Cyprus Anvil Mining Corporation was formed in April 1975 by the amalgamation of Anvil Mining Corporation Limited and Dynasty Explorations Limited on a share-for-share basis. Cyprus Mines Corporation, which holds 63.05 per cent of the issued shares, controls the new company. Production in 1975 was back to normal after output had been reduced in 1974 by a 33-day work stoppage. Output of lead in concentrates was 116,161 tons in 1975. Ore reserves are reported as 47 million tons grading 8.7 per cent combined lead-zinc and 1.0 ounce of silver a ton.

At United Keno Hill Mines Limited production was at the same level as in 1974. Ore reserves declined at the company's Husky mine, the main production unit, and the Townsite mine was closed during the year because of low-grade production. Reserves at year-end are listed as 121,727 tons grading 4.7 per cent lead, 1.1 per cent zinc and 39.3 ounces of silver a ton.

Kerr Addison Mines Limited continued exploration and development work at the Grum zinc-lead-silver deposit north of Vangorda Creek in the Faro area. The Grum joint venture is owned 60 per cent by Kerr Addison and 40 per cent by Aex Minerals Corporation, with Kerr Addison being the manager of the property. The companies undertook a $6.25 million program in 1975 which included driving a 2,600-foot exploratory decline to the ore zone, surface diamond drilling, a feasibility study, including metallurgical testing of the ore; and preliminary plant design and environmental investigations. The deposit was reported to contain about 32 million tons grading 10 per cent combined lead-zinc and 2.0 ounces of silver a ton.

Northwest Territories. Lead in concentrate production at Pine Point Mines Limited declined in 1975 to 87,286 tons because of lower mill throughput and treatment of lower-grade ore. A new 600,000-ton ore zone was discovered during the year. Ore reserves at December 31, 1975 were 39 million tons grading an estimated 5.7 per cent zinc and 2.2 per cent lead.

On Baffin Island near Arctic Bay, construction of mine and concentrator facilities for the first commercial mine north of the Arctic Circle in North America continued on schedule. The property is to be operated by Nanisivik Mines Ltd. and Nanisivik is owned 59.50 per cent by Mineral Resources International Limited, 18.00 per cent by the Government of Canada, 11.25 per cent by Metallgesellschaft A.G. and 11.25 per cent by Billiton B.V. Texasgulf Inc. retains a 35 per cent carried interest in the property as original owner, once all development costs have been recovered. Total capital costs for mine and infrastructure are expected to reach about $64 million, including a working capital allowance of $5 million by the time the mine goes into production in late 1976. Ore reserves are reported as 6.9 million tons grading 14.1 per cent zinc, 1.4 per cent lead and between 1 and 2 ounces of silver a ton. Lead recoveries are anticipated to be about 90 per cent, resulting in a production of about 14,000 tons a year of concentrate grading 65 to 70 per cent lead (based on a mining rate of 1,500 tons a day).

At Izok Lake, 224 air miles north of Yellowknife, Texasgulf Inc. has made what might be a very important discovery with regard to future mineral developments in the north. Three sulphide zones have been indicated from diamond drilling results, and the central zone, which is open to the east, contains over 7 million tons of indicated ore grading 14.8 per cent zinc, 3.15 per cent copper, 1.2 per cent lead, and 1.85 ounces of silver a ton. The top of the orebody crops out on an island in the southern part of the lake and preliminary investigations suggest that the ore zone is suitable for open-pit mining methods. Diamond drilling in 1976 will continue on the central zone and the other two zones, which are as yet undelineated.

The Bathurst Norsemines Ltd. property in the Hackett River area continues to be the site of intense exploration activity by Cominco Ltd., which has optioned the property. A $100,000 feasibility study by Wright Engineers is to be undertaken in 1976. Cominco has spent about $2 million on the property to the end of 1975 and under the agreement with Bathurst Norsemines, Cominco can earn a 65 per cent interest

(text continued on page 283)

Table 3. Principal lead mines in Canada, 1975 and (1974)

Company and Location	Mill or Mine Capacity	Grade of Ore Milled: Lead	Zinc	Copper	Silver	Ore Milled	Lead Concentrate Produced	Grade of Lead in Concentrate	Contained Lead Produced[1]	Destination[2] of Lead Concentrate
	(tons ore/day)	(%)	(%)	(%)	(oz/ton)	(tons)	(tons)	(%)	(tons)	
Newfoundland										
ASARCO Incorporated, (Buchans Unit), Buchans	1,250 (1,250)	5.92 (6.28)	10.54 (11.24)	0.95 (1.01)	3.03 (3.25)	232,000 (264,000)	20,247 (23,959)	57.27 (56.43)	13,098 (15,459)	3,7 (5,7)
New Brunswick										
Brunswick Mining and Smelting Corporation Limited, Bathurst	10,000 (10,000)	2.95 (2.96)	7.11 (6.70)	0.40 (0.38)	2.33 (2.32)	3,427,239 (2,607,965)	170,686 (126,030)	34.97 (36.20)	59,689[3] (45,623[3])	1 (1)
Heath Steele Mines Limited, Newcastle	3,100 (3,100)	1.54 (1.72)	3.99 (4.39)	1.03 (1.04)	1.73 (1.98)	1,089,443 (1,085,495)	31,048 (34,576)	26.48 (27.61)	10,354 (12,017)	3,5,6,8 (3,5,8)
Nigadoo River Mines Limited, Bathurst	1,000 (1,000)	2.55 (2.53)	2.69 (2.74)	0.25 (0.33)	3.44 (3.79)	255,078 (205,691)	8,407 (9,026)	52.11 (48.81)	5,688 (4,406)	2 (2)
Quebec										
Manitou-Barvue Mines Limited, Golden Manitou Mine, Val d'Or	1,600 (1,600)	0.30 (0.35)	1.81 (2.20)	— (—)	2.46 (2.58)	244,995 (225,303)	1,472 (1,422)	30.0 (36.7)	443 (521)	3 (3)
Sullivan Mining Group Ltd., Stratford Centre, Cupra Division	1,400 (1,500)	0.47 (0.59)	4.12 (4.78)	2.24 (2.49)	0.972 (1.112)	56,058 (87,478)	253 (507)	61.58 (63.18)	156 (320)	2 (2)
D'Estrie Mining Company Ltd.	Treated at Cupra Mill	0.54 (0.61)	2.12 (2.72)	2.57 (2.56)	1.116 (1.155)	180,094 (162,081)	939 (961)	61.41 (63.57)	576 (611)	2 (2)
Clinton Copper Mines Ltd.	Treated at Cupra Mill	0.47 (0.48)	2.49 (2.50)	2.59 (2.64)	0.876 (0.951)	73,535 (52,656)	225 (163)	59.32 (56.64)	133 (93)	2 (2)

Table 3.(cont'd)

Company and Location	Mill or Mine Capacity	Grade of Ore Milled				Ore Milled	Lead Concentrate Produced	Grade of Lead in Concentrate	Contained Lead Produced[1]	Destination[2] of Lead Concentrate
		Lead	Zinc	Copper	Silver					
	(tons ore/day)	(%)	(%)	(%)	(oz/ton)	(tons)	(tons)	(%)	(tons)	
Ontario										
Falconbridge Copper Limited, Sturgeon Lake Joint Venture, Sturgeon Lake	1,200 (1,200)	1.17 (1.09)	9.07 (7.59)	2.78 (2.05)	5.31 (. .)	376,682 (82,592)	2,481 (. .)	7.78 (10.95)	279 (71)	8 (3)
Mattabi Mines Limited, Sturgeon Lake	3,000 (3,000)	0.70 (0.91)	7.34 (8.81)	0.97 (0.91)	3.23 (4.31)	1,074,923 (1,138,965)	3,939 (9,428)	50.77 (46.19)	2,000 (4,355)	2,6 (2)
Noranda Mines Limited, Geco Division, Manitouwadge	5,000 (5,000)	. . (0.20)	3.54 (4.72)	1.84 (1.72)	1.44 (1.56)	1,599,333 (1,826,704)	1,894 (3,200)	47.94 (53.94)	908 (1,731)	2 (2)
Texasgulf Canada Ltd., Kidd Creek Mine, Timmins	10,000 (10,000)	0.25 (0.30)	8.20 (9.20)	1.71 (1.75)	3.10 (3.17)	3,630,224 (3,723,865)	31,573 (36,189)	12.83 (13.77)	4,051 (4,198)	3 (. .)
Willroy Mines Limited, Manitouwadge Division	1,400 (1,700)	0.22 (0.23)	3.82 (3.06)	0.42 (0.42)	1.56 (1.37)	327,353 (394,154)	1,416 (. .)	30.99 (36.79)	439 (550)	2 (2)
Manitoba and Saskatchewan										
Hudson Bay Mining and Smelting Co., Limited., Flin Flon	8,500 (8,500)	0.20 (0.12)	3.0 (3.2)	2.4 (2.3)	0.60 (0.63)	1,470,157 (1,574,948)	229 (72)	69.9 (65.9)	160 (47)	2 (2)
British Columbia										
Cominco Ltd., Sullivan mine, Kimberley	8,000 (10,000)	3.85 (4.11)	4.16 (4.49)	– (. .)	1.27 (1.41)	2,207,848 (1,416,489)	94,547 (71,007)	62.92 (63.16)	71,248 (51,837)	2 (2)
HB mine, Salmo	1,200 (1,200)	0.56 (1.1)	3.40 (3.7)	– (–)	. . (. .)	453,145 (256,121)	5,496 (4,300)	23.5 (40.0)	1,628 (2,235)	2 (2)
Consolidated Columbia River Mines Ltd. (N.P.L.), Ruth Vermont mine	500 (–)	. . (–)	. . (–)	. . (–)	. . (–)	11,308 (–)	392 (–)	50.20 (–)	208 (–)	2 (–)

Table 3. (concl'd)

Company and Location	Mill or Mine Capacity	Grade of Ore Milled				Ore Milled	Lead Concentrate Produced	Grade of Lead in Concentrate	Contained Lead Produced[1]	Destination[2] of Lead Concentrate
		Lead	Zinc	Copper	Silver					
British Columbia (cont'd)										
Kam-Kotia Mines Limited Venture, Silmonac mine, Sandon	120 (140)	5.66 (3.28)	4.82 (4.16)	— (—)	17.48 (12.76)	12,045 (12,034)	1,082 (726)	58.74 (54.71)	652 (397)	2 (2,3)
Reeves MacDonald Mines Limited, Remac, Annex mine	1,000 (1,000)	0.58 (1.18)	3.07 (3.84)	— (—)	0.60 (0.64)	35,507 (195,565)	301 (2,926)	11.19 (60.31)	167 (1,681)	3 (3)
Teck Corporation Limited, Beaverdell mine, Beaverdell	110 (110)	0.38 (0.41)	0.39 (0.52)	. . (—)	9.30 (9.06)	38,469 (37,184)	776 (1,037)	16.16 (13.28)	146 (154)	2 (2)
Western Mines Limited, Lynx and Myra Falls, Buttle Lake V.I.	1,100 (1,100)	1.42 (1.48)	7.59 (8.05)	1.12 (1.28)	4.49 (4.52)	287,393 (297,290)	7,613 (8,648)	43.50 (39.82)	3,813 (4,060)	2 (2)
Yukon Territory										
Cyprus Anvil Mining Corporation, Faro	10,000 (10,000)	4.03 (4.51)	5.41 (5.60)	— (—)	. . (. .)	3,225,223 (2,925,000)	145,453 (148,517)	66.89 (64.99)	116,161 (103,135)	2,3,4,5,7,8 (4,5)
(Also bulk lead-zinc concentrate)							77,113 (72,294)	18.37 (18.65)	Included above	
United Keno Hill Mines Limited, Elsa, Husky, No cash mines, Elsa	500 (225)	4.03 (4.22)	1.15 (1.15)	— (—)	34.96 (37.73)	90,860 (93,232)	6,130 (6,839)	53.57 (52.79)	3,284 (3,368)	3 (3)
Northwest Territories										
Pine Point Mines Limited, Pine Point	10,000 (11,000)	2.37 (2.58)	4.88 (5.28)	— (—)	— (. .)	3,904,677 (4,135,380)	104,275 (123,101)	78.16 (76.81)	87,286 (100,883)	2,3,4,8 (2,8)

Source: Data supplied by companies to Mineral Development Sector, Department of Energy, Mines and Resources, Ottawa.
[1]Total lead contained in all concentrates. [2]Destination: (1) Brunswick Mining and Smelting Corp; (2) Cominco Ltd.; (3) U.S.A.; (4) Japan; (5) Germany; (6) Belgium; (7) United Kingdom; (8) Unspecified or other countries. [3]Calculated from grade and amount of lead concentrates.
— Nil; . . Not available.

Table 4. Prospective lead producing mines

Company and Location	Year Production Expected	Mill or Mine Capacity	Indicated Ore Reserves	Grade of Ore: Zinc	Grade of Ore: Lead	Grade of Ore: Copper	Grade of Ore: Silver	Remarks
		(tons ore/day)	(tons)	(%)	(%)	(%)	(oz/ton)	
Ontario								
Mattagami Lake Mines Limited, Lyon Mine, Sturgeon Lake	1978	—	4,030,000	6.66	0.63	1.15	3.39	Ore to be processed at Mattabi Mines Ltd. at rate of 1,000 tons a day.
British Columbia								
Northair Mines Ltd., Brandywine Falls	1976	300	459,000	3.09	2.28	0.33	3.20	Start-up expected early 1976.
Northwest Territories								
Nanisivik Mines Ltd. Strathcona Sound	1976	1,500	6,900,000	14.1	1.40	—	1.77	Construction commenced in 1974. Satisfactory progress to date. Initial output expected in late 1976 with shipments commencing in 1977.

Sources: Company reports and technical press.
— Nil.

Table 5. Indicated lead deposits under exploration

Company and Location	Indicated Ore Tonnage	Grade of Ore: Zinc	Grade of Ore: Lead	Grade of Ore: Copper	Grade of Ore: Silver	Remarks
	(tons)	(%)	(%)	(%)	(oz/ton)	
Nova Scotia						
Cuvier Mines Ltd., Gays River	12,000,000	5.60	2.3	—	. .	Optioned to Imperial Oil Limited. Under exploration since 1972. Full potential not determined yet. Intensive program continuing 1976, including production feasibility study.
New Brunswick						
Anaconda Canada Limited, Bathurst, Caribou property	50,000,000	4.43	1.7	0.47	. .	In temporary production in 1971 and 1974. Feasibility studies continue on bringing this property into production (late 1970's?).

Chester Mines Limited, Newcastle	1,600,000	2.12	0.82	0.63	. .	Ore available for open-pit mining.
	3,300,000	. .	—	0.82	—	
	13,000,000	. .	—	0.77	. .	Ore available for underground mining. Feasibility study completed in 1970.
Key Anacon Mines Limited, Bathurst	1,950,000	5.87	2.18	0.24	2.31	Mine partly developed. Revaluation of property in 1970 led to decision to defer placing the property into production at that time.
Canex Placer Limited, Portage Lakes area, Restigouche property	3,000,000	6.0	4.5	. .	2.50	Partly recoverable by open pit. Further exploration in 1975.
Texasgulf Inc., Half Mile Lake	6,800,000	6.5	2.5	. .	. .	Texasgulf is considering sinking an exploratory shaft to the ore zone.
Ontario						
Giant Yellowknife Mines Ltd., Errington and Vermilion Lake mines, Sudbury area	4,418,500	3.9	1.0	1.33	1.61	Extensive underground development in 1961-1967 period. Ore difficult to concentrate. Reserves only for underground explored areas with low pyrite and high pyrite ore respectively.
	and					
	9,038,317	3.82	0.99	1.14	1.58	
Yukon Territory						
Hudson Bay Mining and Smelting Co., Limited, Tom deposit, MacMillan Pass	7,000,000	8.4	8.1	—	2.75	Underground work through adit including diamond drilling in 1970-72. Further development planned.
Kerr Addison Mines Limited, Swim Lake deposit, Vangorda Creek	5,000,000		9.5 (Pb+Zn)	. .	1.50	A group claims.
Kerr Addison Mines Limited, — Aex Minerals Corporation, Grum Deposit, Vangorda Creek	30,000,000	. .	About 10 (Pb+Zn)	. .	2.00	Similar to Cyprus Anvil lead-zinc deposit. Possibly 50 million tons ore. $6.25 million program undertaken in 1975, including 2,600 ft. decline into ore body.
Vangorda Mines Limited, Vangorda Creek	9,400,000	4.96	3.18	0.27	1.76	Feasibility study made. No further exploration.
Canex Placer Ltd., Howards Pass, Summit Lake	300,000,000		About 5-10 (Pb+Zn)			Joint exploration with U.S. Steel. Drilling to continue in 1976.

Table 5 (concl'd)

Company and Location	Indicated Ore Tonnage	Grade of Ore: Zinc	Lead	Copper	Silver	Remarks
	(tons)	(%)	(%)	(%)	(oz/ton)	
Northwest Territories						
Welcome North Mines Ltd., Bear Property, Godlin Lake	20,000,000		About 7-8 (Pb+Zn)	. .	0.5-1.0	Drilling continues.
Arvik Mines Ltd., Little Cornwallis Island	25,000,000	14.1	4.3	. .	1.0	Cominco Ltd. — 75% and Bankeno Mines Limited — 25%. Underground program (5,300-foot adit) and metallurgical tests completed. Feasibility study completed. Decision on mining to be made in 1976.
Buffalo River Exploration Limited	1,350,000	9.6	3.4	—	. .	Feasibility study for joint production with Coronet Mines Ltd. completed in 1971. Decision made not to put the property into production at present.
Bathurst Norsemines Ltd., Hackett River, Bathurst Inlet area	20,000,000	. .	. .	. .	. .	Optioned to Cominco. Large deposit in three zones with high zinc and silver values. Under active exploration from 1970, and $2 million expended to December 1975. Wright Engineers performing $100,000 feasibility study 1976.
Texasgulf Inc., Izok Lake	7,000,000	14.8	1.2	3.15	1.85	Central ore zone, which is open to east. Remaining two zones not delineated and drilling to resume April 1976.

Sources: Company reports and technical press.
. . Not available; — Nil.

in Bathurst by spending $6 million on exploration, development, and financing the property to the production stage. Ore reserves in the three main zones; the Boot Lake, East Cleaver Lake and the Main, are estimated at 20 million tons of good-grade lead-zinc material. Several other rich sulphide zones are still being investigated. All zones are open laterally and at depth.

Arvik Mines Ltd., owned 75 per cent by Cominco and 25 per cent by Bankeno Mines Limited, reported that although discussions continued with the Federal Government during 1975, progress was disappointingly slow with regard to development of the Polaris deposit on Little Cornwallis Island in the high arctic. If problems between the two parties are resolved in the near future, a production decision could be made in 1976 or 1977. The deposit contains an estimated 25 million tons grading 14.1 per cent zinc, 4.3 per cent lead and 1.0 ounce of silver.

Metal production

Production of refined primary lead metal in Canada during 1975 was 189,064 tons compared with 139,380 tons in 1974. Collectively, the two Canadian lead metal producers operated at 76 per cent of capacity during 1975 in order to keep output in line with reduced market demand for metal.

Table 6. United States consumption of lead by end-use, 1974-75

	1974	1975[p]
	(short tons)	
Storage batteries	851,881	584,549
Gasoline antiknock additives	250,502	208,605
Solder, type metal, terne metal and bearing metals	103,705	65,775
Ammunition and collapsible tubes	89,578	77,144
Pigments	116,213	71,217
Cable sheathing	43,426	21,505
Sheet and pipe	37,749	28,885
Caulking	19,739	10,567
Miscellaneous	86,634	42,528
Total reported[1]	1,599,427	1,110,775
Estimated undistributed consumption	–	120,000
Grand Total	1,599,427	1,230,775

Source: United States Department of the Interior, Bureau of Mines Mineral Industry Surveys, Lead Industry in December 1975.
[1]Includes lead content of scrap used directly in fabricated products.
[p]Preliminary; – Nil.

Cominco Ltd.'s lead smelter and refinery at Trail, B.C. was shut down during the month of August for maintenance and as an inventory control measure. The plant was operated at a reduced output level for the rest of the year. A new 850-ton-a-day sulphuric acid plant began operations during the year and two older plants at Trail were shut down.

The lead plant owned by Brunswick Mining and Smelting Corporation Limited at Belledune, N.B. was operated below capacity during the year because of production difficulties and inventory control measures. Production at this plant is expected to increase in the coming years as difficulties associated with switching the plant from an Imperial Smelting Process operation producing lead and zinc metal, to a straight lead producer are overcome.

Developments in the United States

The United States continued to be the world's largest mine producer, refined metal producer and consumer of lead. Mine production of lead decreased in 1975 to 634,269 tons, 6.5 per cent below the 1974 level.

Missouri was the principal producing state, accounting for 83 per cent of the U.S. output. Primary refined metal production decreased 6.0 per cent to 641,120 tons, while secondary refined production dropped 12.5 per cent to about 610,000 tons.

Releases from the United States government stockpile, administered by the General Services Administration, totalled 7,000 tons in 1975, a good indicator of the low level of business activity in the U.S. when compared with the release of 224,000 tons in 1974. There were no sales from the stockpile in the third and fourth quarters of 1975 because producer stocks had risen above the trigger level of 52,000 tons. At the end of 1975, there were approximately 600,000 tons left in the stockpile of which 72,000 are authorized for sale once producer stocks drop below the 52,000 level.

Canadian exports of refined metal to the U.S. decreased from 52,898 tons in 1973 to 25,543 tons in 1975, partly a result of declining demand but more importantly a result of the January 1974 dumping ruling by the International Trade Commission (ITC) against Australian and Canadian lead producers. A re-hearing of the case was scheduled for July 1975 by ITC but the meeting was postponed until February 1976, at which time the original decision was reversed and the dumping ruling revoked.

The Environmental Protection Agency's (EPA) regulations for the phase-down of lead in gasoline which were to have come into effect on January 1, 1975, were challenged by lead additive manufacturers and the National Petroleum Refiners Association on the grounds that health hazards from lead emissions had not been proven. The U.S. Court of Appeals had set aside the EPA regulations in a ruling in December 1974. An EPA appeal resulted in the 1974 decision being vacated and a re-hearing by the full nine-judge Court being granted. The re-hearing was not held until

May 1975 and the decision was given in March 1976. The court in a 5 to 4 decision, upheld the right of the EPA to reduce the levels of lead-in-gasoline. It is likely that this decision will be appealed by the parties concerned. If the ultimate decision is in favour of the phase-down, the use of lead in gasoline could decrease to about 140,000 tons by 1980 (1975 consumption was 208,605 tons).

World developments

The lead industry suffered through a depressing economic year: mine production of lead was static; metal production decreased 10.4 per cent; and consumption declined 18.0 per cent from the 1974 level.

Table 7. Noncommunist world mine production of lead, 1974-75

	1974	1975p
	(short tons)	
United States	678,802	634,269
Australia	396,832	422,736
Canada	346,346	383,935
Peru	221,785	209,439
Mexico	186,290	179,677
Yugoslavia	120,482	128,419
Morocco	94,799	93,696
Sweden	80,138	75,839
Spain	71,099	63,383
Republic of South Africa	60,076	57,210
Japan	48,722	55,777
Ireland	37,919	47,399
West Germany	38,581	41,226
Argentina	40,785	36,376
Denmark	26,455	29,762
Italy	26,015	29,542
Brazil	29,762	27,558
Other	257,060	264,885
Total	2,761,948	2,781,128[1]

Source: International Lead and Zinc Study Group, Monthly Bulletin, May, 1976.
[1]Total includes estimates for those countries for which figures are not available.
[p]Preliminary.

Mine Production. Noncommunist world mine production of lead in 1975 was 2,781,128 tons compared with 2,761,948 tons in 1974. Most countries reported a decline in mine production in 1975 but the most notable exceptions to this general trend were Canada (up 37,000 tons) and Australia (up 26,000 tons). Both Canadian and Australian production rebounded from strike-reduced levels in 1974.

Three new mines came into production in 1975; one each in Spain, Mexico and the United States. Including expanded mine capacity in Japan, the additions to world mine capacity totalled 19,000 tons. These additions were balanced by mine closures in Canada, Mexico and Morocco.

Metal Production. Noncommunist world production of lead metal from both primary and secondary sources dropped from 3,951,340 tons in 1974 to 3,541,722 tons in 1975. Declining demand for metal during the last quarter of 1974 and for most of 1975 forced many companies to keep production levels well below capacity for extended periods in 1975. Only four countries showed an increase in metal production: Canada, 50,000 tons; Argentina, 10,000 tons; Belgium, 9,000 tons and Yugoslavia, 8,000 tons. The large increase in Canadian production was a result of normal operations prevailing at Cominco's Trail, B.C. plant after a four-month strike affected production in 1974.

Two new secondary lead smelters started operations in 1975, adding 35,000 tons to world capacity. Table 10 shows expected new plants and additions to capacity in the period 1976 to 1979.

Table 8. Noncommunist world production[1] of refined lead, 1974-75

	1974	1975p
	(short tons)	
United States	1,243,406	1,111,239
West Germany	351,637	285,498
United Kingdom	251,327	214,289
Australia	247,799	207,896
Mexico	224,871	196,211
Canada	139,442	188,826
France	195,880	165,567
Yugoslavia	126,435	138,891
Belgium	104,389	113,538
Spain	112,766	94,137
Italy	123,238	85,760
Peru	88,405	77,272
Brazil	81,571	71,650
Argentina	56,218	66,139
Republic of South Africa	70,878	52,360
Sweden	45,084	40,675
Tunisia	29,101	26,896
Other	458,893	404,878
Total	3,951,340	3,541,722

Source: International Lead and Zinc Study Group, Monthly Bulletin, May, 1976.
[1]Total production by smelters or refineries of refined pig lead, plus the lead content of antimonial lead — including production on toll in the reporting country — regardless of the type of source material; i.e. whether ores, concentrates, lead bullion, lead alloys, mattes, residues, slags or scrap. Remelted pig lead and remelted antimonial lead are excluded.
[p]Preliminary.

Table 9. Canada, lead production and consumption, 1973 to 1976, and 1980

	1973	1974	1975	1976[f]	1980[f]
	(thousands of tons)				
Mine Production	427	332	376	380	430
Metal Production	206	139	189	200	230
Consumption	119	116	90[e]	100	135

[e]Estimate; [f]Forecast.

Consumption. Preliminary estimates from the International Lead and Zinc Study Group (ILZSG) indicate that consumption declined 18 per cent in 1975 to 3,336,000 tons, down 730,000 tons from the 1974 level of 4,066,000 tons. Every major country was affected by the economic downturn. The automobile and construction sectors were particularly hard hit.

When allowing for net exports of 57,000 tons to socialist countries and sales of 7,000 tons of lead by the GSA from the United States' stockpile, the statistical summary for 1975 indicates a surplus of 155,000 tons.

Outlook

Canada. A forecast for Canadian production and consumption to 1980 is shown in Table 9. A slow but continued improvement in economic conditions in 1976 is the major factor in predicting an increase in mine and metal output, but the level of activity will still be lower than in 1973.

Mine production is shown as only increasing very slightly by 1980 from the 1973 level of output. New production will come from mines in Ontario, British Columbia and the Northwest Territories. Expanded mine capacity will also result in increases in mine production in New Brunswick and Ontario. Most of this expansion will probably be balanced by declining production from other producers in Newfoundland, Ontario and the Yukon Territory. Mine production forecasts could be on the conservative side for 1980 if certain projects such as Gays River, Grum or Arvik reach the production stage sooner than expected. The increased metal output will result from higher utilization of existing plant capacity, presently 250,000 tons a year. Growth in consumption is based on a 2 per cent growth rate, indicative of slow but steady growth in such sectors as the battery and construction industries which will more than compensate for any losses in the chemicals sector (gasoline additives).

World. The International Lead and Zinc Study Groups (ILZSG) has forecast that mine production will show a modest increase in 1976 of approximately 70,000 tons. Morocco and Peru will show the largest increase from new sources, with the Touisset project in Morocco being the largest individual producer scheduled to achieve full production in 1976 (about 38,000 tons of lead mine output). New projects or expansions are also scheduled for Yugoslavia, Mexico, India and Iran. New projects scheduled to come on stream in the period 1977 to 1980 could add 330,000 tons to world mine capacity, with the largest project being the Navan mine in Ireland, having a capacity of 52,000 tons of lead mine output.

Projects reported for start-up in 1976 by the ILZSG will result in world metal production capacity being increased by 184,000 tons, with 124,500 tons coming from new plants or additions in the primary sector. Actual metal production for 1976 is forecast to increase by almost 400,000 tons, but this is still below the 1973 production level. In 1976, new plants or expansions of existing plants are scheduled for Denmark, Italy, Sweden, Morocco, Mexico and India. New capacity will add 456,000 tons to world capacity by 1979. Of this total, 215,000 tons is in the primary sector and 241,000 tons in the secondary sector. Total noncommunist world installed primary metal capacity could be in the order of 3.9 million tons by 1980. With an effective utilization capacity of 90 per cent, this means that output could be 3.5 million tons if supplies of concentrates are sufficient and demand warrants it. Table 11 indicates that by 1980, assuming a growth rate in consumption of between 1.5 and 2.0 per cent per annum, both a shortage of lead in concentrates and total lead metal is a possibility. Such a deficit would have to be made up by releases from the United States government stockpile, trade with eastern European countries, and increased production from the secondary sector (along with some scrap being used as feed in primary plants).

Uses

Lead has many useful chemical properties and, because of this versatility, it has a variety of industrial applications. It is soft, ductile, alloys readily with other materials, has good corrosion resistance, a high boiling point, a low melting point and a high specific gravity. Lead is one of the oldest metals known to man and since medieval times has been used in piping, building materials, solders, paint, type metal, ammunition and castings.

Lead is used mainly in lead-acid storage batteries, the bulk of which are used for starting, lighting and ignition(SLI) in automobiles and trucks. Recent improvements in battery manufacture have significantly reduced the weight of lead in a battery unit and

Table 10. Location of new or expanded smelter capacity

Expected Start-up Year	Country	Company	Location	Type of Plant	Capacity (metric tons a year)	Remarks
1976	Denmark	Bergsoe	Glostrup	Secondary smelter	30,000	Replacing existing plant of 20,000 tonnes capacity.
	Italy	. .	Northern Milan	Secondary smelter	10,000	Two new plants.
	Sweden	Bergsoe	Landskrona	Secondary smelter	30,000	Replacing existing plant of 22,000 tonnes capacity.
	Morocco	Zellidja	Oued-el-Heimer	Smelter & refinery	40,000	New plant.
	Mexico	Penoles	Torreon	Refinery	190,000	Replacing existing plant of 120,000 tonnes capacity.
	India	Hindustan Zinc	Tundoo, Bihar	Pyrometallurgical plant	3,000	Expansion of existing capacity of 3,000 tonnes.
		India Lead Alloys	Bombay	Secondary smelter	6,000	Expansion of existing plant.
1977	Spain	Syndicate of 6 companies	Linares	Smelter	40,000	Replacing old plant of 18,000 tonnes capacity.
	Turkey	Cinkur & Etibank	Kayseri	Smelter	3,000	New plant.
	Brazil	Tonolli	Jacarei	Secondary smelter	40,000	New plant.
	India	Hindustan Zinc	Vishakhpatnam	Pyrometallurgical smelter	10,000	New plant — under construction.
		India Lead Alloys	Calcutta	Secondary smelter	18,000	New plant.
1978	United Kingdom	Britannia Lead Co.	Northfleet	Secondary smelter	30,000	New plant — under construction.
	Brazil	COBRAC	St. Amaro	Smelter	13,000	Expansion of existing plant of 44,000 tonnes capacity.
	United States	N L Industries	Pedritoron, N.J.	Secondary Smelter	65,000	Expansion from 35,000.
			Beech Grove, Ind.	Secondary Smelter	70,000	Expansion from 30,000.
			Los Angeles, Cal.	Secondary Smelter	65,000	Expansion from 35,000.
1979	Brazil	Metamig	Paracatu	Smelter	11,000	New plant for treating sulphide ores.

Sources: International Lead and Zinc Study Group and technical press.
. . Not available.

Table 11. Forecasts of noncommunist[1] world mine and metal production, and consumption by 1980

	Base Year[2]	1975	1976	1980
	(thousands of metric tons)			
Mine Production	2,814	2,781	2,850	3,150
Metal Production[3]	3,930	3,542	3,920	4,350
Consumption	4,093	3,336	3,600	4,475 -4,610[4]
Statistical Balance[5]		+155	+230	-125 to -260

Source: Mineral Development Sector, Department of Energy, Mines and Resources, Ottawa.
[1]Includes Yugoslavia. [2]Average of 1973 and 1974. [3]Includes secondary metal production. [4]Consumption is presented in a range with the lower limit corresponding to a 1.5 per cent annual growth rate and the upper limit a 2.0 per cent annual growth rate. [5]The balance includes releases from the United States government stockpile and the net trade with communist countries (for 1975 and 1976 but not for 1980).

increased the average battery life and performance. However, lead usage in SLI batteries is expected to continue to grow, and by 1980 to account for about 50 per cent of total lead consumption. This growth will come from increased automobile production and from rapid growth in the use of electric-powered industrial trucks (particularly fork-lift vehicles). Many governments in Europe and North America have experimental transportation programs involving battery systems as the power source, replacing the internal combustion engine.

The next most important use of lead is as an antiknock additive in gasoline. Lead consumed for batteries and gasoline additives in 1975 accounted for 70 per cent of the total lead consumption in the United States. The metal is also used extensively for cable sheathing, collapsible tubes, caulking materials, corrosive-liquid containers, galvanizing spelter and lead-base babbitts. Although lead usage for metal sheathing was on the decline in most industrialized countries, it has experienced some revival as a result of export orders, particularly to the Middle East.

The commercial and residential construction industry is a growing market for lead in the form of sound-proofing, flashing and construction panels. Because of its unique sound control characteristics there is an expanding use for lead in sound attenuation both as sheets and lead-composition panelling. Composite thermal-acoustical panels are now being used to contain the noise from industrial plants. The International Lead Zinc Research Organization, Inc. (ILZRO) has designed and constructed an all-metal house requiring a minimum of maintenance and containing approximately 1.5 tons of lead and zinc. Lead-coated steel sheeting (terne steel) that combines lead's corrosion resistance and sound-barrier properties with the strength of steel is now available for many building applications. Terne steel is sheet steel coated with an alloy containing 85 per cent lead. In the allied field of vibration isolation, lead-asbestos antivibration pads are now being widely used in foundations for office buildings, and in hotel and apartments exposed to severe vibration from nearby heavy traffic. Because of its sound-control qualities, lead is also used in the mounting of various types of equipment, including air-conditioning systems, heavy industrial equipment and commercial laundry machines.

The use of chrome yellow (lead chromate) paints on highways for pavement marking is growing because it is the most versatile low-cost pigment available for traffic-control paints.

Miscellaneous uses for lead include automotive wheel weights, ship ballast, and various alloys, and as lead-ferrite for permanent magnets in small electric motors. Relatively new and growing areas of use are for leaded-procelain enamel in coating aluminum and for radiation shielding against gamma rays in nuclear-powered reactors, nuclear-powered ships and submarines, and shipping casks for transporting radioactive materials. Continuing research has developed new and promising markets for organometallic lead compounds in such applications as anti-fouling paints, wood and cotton preservatives, lubricant-oil additives, polymethane foam catalysts, molluscicides, antibacterial agents and rodent repellents.

Refined lead is marketed in several grades that vary mainly according to the content of impurities, including silver, copper, arsenic, antimony, tin, zinc, iron and bismuth. The three principal grades are corroding, chemical, and common desilverized lead. The corroding grade has the highest purity and is used chiefly in the manufacture of pigments, battery oxides and tetraethyl lead. Common lead is used mostly in industrial and home construction, while chemical lead possesses superior creep and corrosion resistance and is ideally suited for cable sheathing.

Prices

Prices for lead metal in all major industrial markets declined during 1975. Inventories increased rapidly until mid-year, but there was some amelioration during the second half, which left consumer and producer stock totals only marginally increased during the year.

There was also a shift of stocks from producers to consumers in the fourth quarter, which resulted in a slight price increase in the North American market. However, the producers were forced to retract the increase, as it became evident that the stock movement did not extend to the ultimate consumer.

The Canadian domestic price of lead, virgin delivered, opened the year at 21.5 cents a pound and held until May 15. The price was then adjusted downwards to 20.75 cents until June 3, after which two further price declines of 1.25 cents on June 4 and 1.0 cent on December 17 brought the price to 18.5 cents a pound. This price remained in effect during the rest of December.

In the United States the price activity was much the same, with the price opening the year at 24.5 cents a pound and then declining to 19.0 cents a pound at year-end. There was a 1.0 cent a pound increase during August to 20.0 cents a pound, but by the end of November, lack of consumer interest forced the price back to the 19.0 cent level.

On the London Metal Exchange (LME) the spot-price high for the year of £229 a metric ton was recorded on January 2. The price then fell rapidly to a low of £142 a metric ton on May 30 (15.2 cents a pound Canadian). Although the LME quote bounced back into a range of £150 to £180 in the last half, the deteriorating value of sterling actually resulted in a Canadian-price-equivalent low of 14.8 cents a pound being reached on November 24, 1975 (LME quote of £158 a metric ton). The LME price at year-end was £164 a metric ton (15.7 cents a pound Canadian).

The lead industry appears to be entering a period of recovery in 1976 and the price of lead in major markets should move upwards accordingly, but there is not likely to be a rapid price take-off on the LME because of high inventories. The spring and fall are likely periods for upward price movements. It will probably be late 1976 or well into 1977 before the lead price moves back to the 24.5-cents-a-pound level in the North American market.

Prices

Canada

The Canadian price of lead, virgin delivered, throughout 1975, was as follows:

			(¢/lb)
Jan. 1	–	May 15	21.50
May 16	–	June 3	20.75
June 4	–	Dec. 16	19.50
Dec. 17	–	Dec. 31	18.50

Source: *The Northern Miner.*

United States

The United States price of lead, U.S. currency, producer delivered in 1975, was as follows:

Jan. 1			24.50
High	–	Jan. 1	24.50
Low	–	Dec. 15	19.00
End of year			19.00
Yearly Average			21.48

Source: *The Northern Miner.*

Great Britain

The London Metal Exchange price of lead was as follows:

			Bid		Asked	
High	–	Jan. 2	£229.000	–	229.500	per metric ton
Low	–	May 30	£142.00	–	143.500	per metric ton

Source: *Metals Week.*

Tariffs

Canada

Item No.		GSP[1]	British Preferential	Most Favoured Nation	General
32900-1	Ores of lead	free	free	free	free
33700-1	Lead, old scrap, pig and block	free	free	free	1¢/lb
33800-1	Lead, in bars and in sheets	3%	5%	5%	25%
33900-1	Manufactures of lead n.o.p.	11½%	17½%	17½%	30%

United States

USTS No.	Effective November 21, 1975	GSP	Most Favoured Nation (¢ per lb on lead content)
602.10	All lead-bearing ore	free	0.75
624.02	Unwrought		
624.03	Lead bullion, other	free	1.0625
624.04	Lead waste and scrap		

European Economic Community (EEC)

BTN No.		GSP	Most Favoured Nation
26.01	Lead ore and concentrates	free	free
78.01	Unwrought lead:		
	For refining (i.e. argentiferous)	free	free
	Other (Jan. 1, 1976)	3.5%	3.5%
	Lead waste and scrap	free	free

Japan

BTN No.		GSP	Most Favoured Nation
26.01	Lead ore and concentrates	free	free
78.01	Unwrought lead:		
	Unalloyed	free	7.5%
	Alloyed	free	7% or 12%
	Lead waste and scrap	free	5%

Sources: For Canada, the Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa. For United States, Tariff Schedules of the United States Annotated (1975), T.C. Publication 706. For Japan, Customs Tariff Schedules of Japan, 1975, Japan Tariff Association. For EEC, Official Journal of the European Communities, Vol. 18, No. L304, 1975.
[1]GSP — Generalized System of Preferences extended to all, or most, developing countries.

Lime

D.H. STONEHOUSE

Carbonate rocks, commonly known as limestones, can be classified according to their content of the minerals calcite ($CaCO_3$) and dolomite ($CaCO_3 \cdot MgCO_3$). They range from calcium limestone containing less than 10 per cent magnesium carbonate to magnesian limestone containing between 10 and 40 per cent magnesium carbonate and to dolomite containing between 40 and 45.65 per cent magnesium carbonate. High-calcium limestones are those with less than 3 per cent total impurities. Limestones vary in colour, texture and hardness as well as in chemical composition, giving rise to a wide range of applications. Quicklime (CaO or $CaO \cdot MgO$) is formed by the process of calcination, in which limestones are heated to the dissociation temperature of the carbonates (as low as 402°C for $MgCO_3$ and as high as 898°C for $CaCO_3$) and held at that temperature over sufficient time to release carbon dioxide. Although the word "lime" is used generally, and wrongly, to refer to pulverized limestone as well as to forms of burned lime, it should refer only to calcined limestone (quicklime) and its secondary products, slaked lime and hydrated lime. Slaked lime is the product of mixing quicklime and water, hydrated lime is slaked lime dried and, possibly, reground.

Calcining is done in kilns of various types but, essentially, those of vertical or rotary design are used, having incorporated many adaptations to the standard designs over the years. Of comparatively recent design are the rotary hearth, travelling grate, fluo-solid and inclined vibratory types. The high cost of energy has made it imperative to include preheating facilities in any new plant design, just as environmental regulations have necessitated the incorporation of dust collection equipment.

Canadian industry and developments

Lime plants have been established near urban and industrial centres in Canada where large reserves of suitable limestone are available and where most of the major consumers of lime are situated. Lime is a high-bulk, low-cost commodity and it is uncommon to ship it long distances when the raw material for its manufacture is available in so many localities. The more heavily populated and industrialized provinces of Ontario and Quebec together produced about 85 per cent of Canada's total lime output in 1975, with Ontario contributing about one-half of Canada's total. More limited markets in the other provinces resulted in much lower production in those areas. Commercial lime (lime that is normally produced for shipment and use off the plant site) was not produced in 1975 in Nova Scotia, Prince Edward Island, Newfoundland or Saskatchewan; the needs in each of these provinces being supplied from plants in neighbouring provinces or states.

During 1975, 18 companies operated a total of 24 lime plants in Canada: one in New Brunswick, four in Quebec, 10 in Ontario, three in Manitoba, four in Alberta and two in British Columbia. A total of 85 kilns was available; 27 rotary, 54 vertical, one vibratory grate and three rotary grate. Preliminary returns indicate that lime production in 1975 was 1,889,000 tons, excluding some captive production such as that from pulp and paper plants that burn sludge to recover lime for re-use in the causticization operation. With apparent production capability in the range of 2.5 to 2.8 million tons a year, capacity utilization in 1975 was about 70 per cent. Production capacity will undoubtedly be increased in certain regions where supply has been running close to demand.

Atlantic provinces. In 1968, at Aguathuna, near Stephenville on the west coast of Newfoundland, Sea Mining Corporation Limited constructed a new plant designed to produce magnesium hydroxide from seawater. Although the plant never operated commercially, a rotary kiln, which was installed to produce lime for captive use in the extraction process, was put into service during 1969 and 1970 to supply some quicklime for waste-neutralization application on the island's east coast. This market is now supplied by Quebec-based lime producers.

Havelock Lime Works Ltd. began production of a high-calcium quicklime early in 1971, utilizing a newly installed, 100-ton-a-day rotary kiln at the company's quarry site at Havelock, New Brunswick. Markets currently include mineral processing operations; pulp and paper industries, mainly within the province; and a growing export trade. Havelock Processing Ltd. now operates the company's crushed limestone plant which has been expanded to offer a range of products from coarse aggregate through washed and screened sizes for asphalt and concrete application to finely pulverized filler material. Snowflake Lime, Limited which, for many years, produced lime at Saint John, has not rebuilt its lime-making facility following a fire in 1968. The quarries are still supplying crushed stone to the local construction industry.

Periodically during the last few years the possibility of establishing a lime producer in the northeast region of New Brunswick has been investigated. Limestone in sufficient quantity and of acceptable quality has been proved in the Elm Tree area but, although market projections indicate an increasing demand for lime in the mining and pulp and paper industries in this area, the amount, in total, does not yet appear to warrant a second plant within the province.

Studies have been made to determine the viability of a lime manufacturing plant in Nova Scotia associated with existing and planned steel producing facilities. Limestone and dolomite for the Sydney steel plant currently come from Irish Cove and Frenchvale, respectively.

Table 1. Canada, lime production and trade, 1974-75

	1974		1975^p	
	short tons	($)	short tons	($)
Production[1]				
By type				
Quicklime	1,754,105		1,656,653	
Hydrated lime	255,179		232,347	
Total	2,009,284	41,811,920	1,889,000	40,439,000
By province				
Ontario	1,053,635	19,374,356	958,000	18,193,000
Quebec	632,571	15,363,874	641,000	15,715,000
Alberta	155,833	3,035,086	133,000	2,659,000
Manitoba	. .	1,830,543	. .	1,584,000
New Brunswick	. .	1,357,036	. .	1,275,000
British Columbia	33,739	851,025	40,000	1,013,000
Total	2,009,284	41,811,920	1,889,000	40,439,000
Imports				
Quick and hydrated				
United States	23,147	754,000	33,066	1,383,000
France	24	15,000	55	36,000
United Kingdom	4	1,000	—	—
Total	23,175	770,000	33,121	1,419,000
Exports				
Quick and hydrated				
United States	425,509	7,857,000	256,614	6,268,000
Panama	700	28,000	1,365	76,000
Total	426,209	7,885,000	257,979	6,344,000

Source: Statistics Canada.
[1]Producers' shipments and quantities used by producers.
. . Not available; ^{p}Preliminary; — Not available.

Table 2. Canada, lime, production, trade and apparent consumption, 1966-75

	Production[1]					
	Quick	Hydrated	Total	Imports	Exports	Apparent Consumption[2]
			(short tons)			
1966	1,293,982	261,055	1,555,037	29,249	180,864	1,403,422
1967	1,178,109	244,790	1,422,899	22,113	90,125	1,354,887
1968	1,219,271	236,742	1,456,013	24,770	85,263	1,395,520
1969	1,388,109	246,753	1,634,862	41,226	195,160	1,480,928
1970	1,401,008	246,946	1,647,954	33,785	200,614	1,481,125
1971	1,379,113	264,465	1,643,578	26,445	283,738	1,386,285
1972	1,486,021	258,135	1,744,156	28,679	296,157[r]	1,476,678[r]
1973	1,631,579	259,011	1,890,590	16,248	373,082	1,533,756
1974	1,754,105	255,179	2,009,284	23,175	426,209	1,606,250
1975[p]	1,656,653	232,347	1,889,000	33,121	257,979	1,664,142

Source: Statistics Canada.
[1]Producers' shipments and quantities used by producers; [2]Production plus imports less exports.
[r] Revised.

Quebec. At Joliette, Domtar Chemicals Limited, Lime Division, produces quicklime and hydrated lime from a high-calcium Trenton limestone for the steel and pulp and paper industries. Plans to double the output capacity of the Joliette plant have been completed. Shipments are made to Atlantic consumers as well as to Quebec and Ontario.

Dominion Lime Ltd. produces high-calcium quicklime and hydrated lime from Silurian limestone at Lime Ridge, near Sherbrooke. Additional production capacity in the form of a new rotary kiln was activated during 1973. Markets include steel, pulp and paper, construction and agricultural industries.

A high-calcium Ordovician limestone of the Beekmantown Formation has been mined for many years by Shawinigan Chemicals Division of Gulf Oil Canada Limited, near Bedford, for use in the company's carbide plant at Shawinigan. The quality of the limestone makes it a highly acceptable material for the production of calcium carbide. Hydrated lime made during calcium carbide-acetylene manufacture is sold for commercial use.

Ontario. Domtar Chemicals Limited, Lime Division, operates a limestone quarry and a lime plant at Beachville. The high-calcium limestone is mined, crushed, screened and used primarily as feed to the lime plant, which has both vertical and rotary kilns. A prolonged strike at the Beachville plant in the latter part of 1975 greatly limited output for the year. At Hespeler, Domtar produces lime, crushed stone and agricultural limestone. The lime plant has vertical kilns and produces high-quality, white quicklime. Both plants also produce hydrated lime.

The Beachville plant of Cyanamid of Canada Limited, containing a rotary kiln and a calcimatic kiln, was sold to Dominion Foundries and Steel, Limited (Dofasco), Hamilton in 1973. Major renovations increased the plant's lime-producing capacity in order to supply increased demands for lime by Dofasco's basic oxygen furnaces. The plant is known as BeachviLime Limited. Cyanamid stopped production from its Niagara Falls plant, the decision being influenced, at least in part, by the necessity to install a dust-collecting system in order to remain in production. Limestone for use as open-hearth and blast-furnace flux, for portland cement manufacture and as a pulverized stone is also produced at Beachville.

Through a subsidiary, Chemical Lime Limited, The Steel Company of Canada, Limited, Hamilton is supplied with flux stone and high-calcium lime from a quarry and lime plant near Ingersoll. Vertical kilns were installed at the lime plant in 1959. A new rotary kiln of 325-ton-a-day capacity was installed in 1971 to supply projected requirements of the company's steel manufacturing facilities at the Hilton Works.

Near Amherstburg, Allied Chemical Canada, Ltd. mines a high-calcium limestone for the production of lime which is used, along with salt from a nearby brine field, in the manufacture of soda ash. Canadian Gypsum Company, Limited produces a dolomitic lime near Guelph. Bonnechère Lime Limited, which operated kilns at Carleton Place and Eganville for many years, discontinued the manufacture of lime in mid-1970.

Early in 1969, Reiss Lime Company of Canada, Limited began construction of docking facilities on Lake Huron, just west of Spragge, to import limestone from the Rogers City area in Michigan for the manufacture of lime to be used in uranium processing. Production of high-calcium lime began in mid-1970 at an initial capacity of 65,000 tons a year. The company is owned by Denison Mines Limited and C. Reiss Coal Co. Wisconsin, U.S.A.

At Dundas, Steetley of Canada (Holdings) Limited produces deadburned dolomite from two rotary kilns, mainly for refractory uses. The company also produces flux stone, crushed stone products and agricultural "lime".

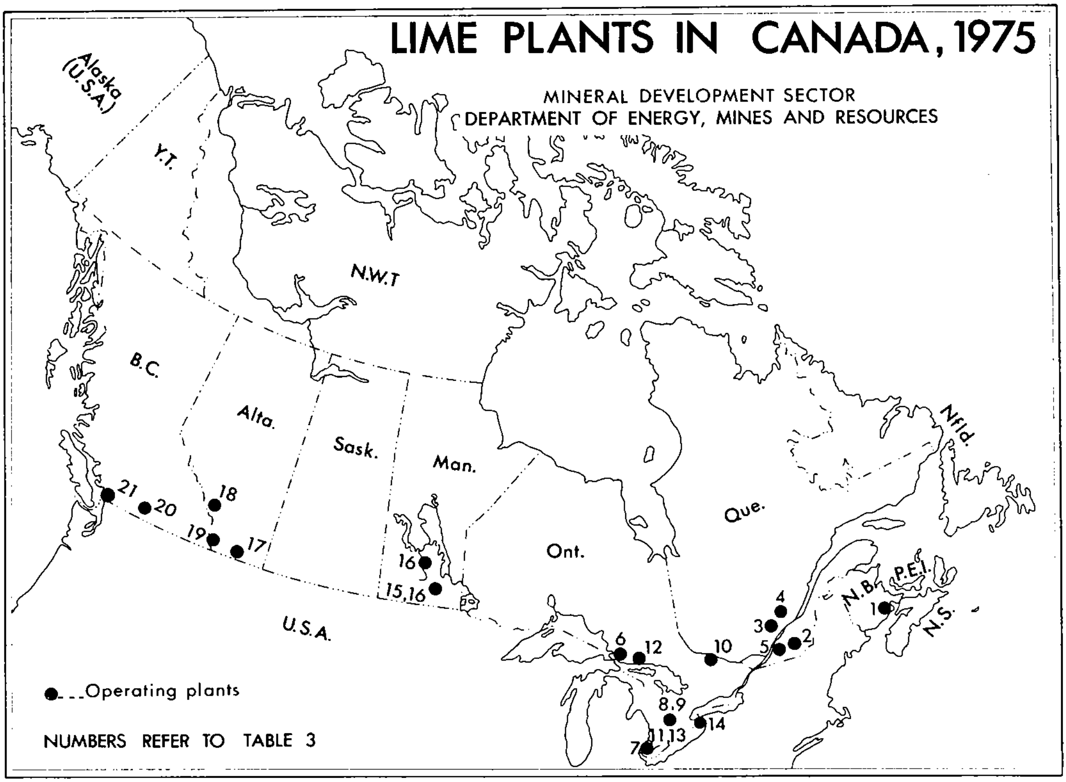
Western provinces. In 1975, Steel Brothers Canada Ltd. operated limestone quarries at Spearhill and Falconer in Manitoba, at Kananaskis, Alberta and at Pavilion Lake in British Columbia. The Spearhill lime plant, from which a white, high-calcium lime was produced, is scheduled to close by mid-1976 when a new rotary kiln at Falconer will be operating. Stone from the Falconer quarry is trucked to the company's Fort Whyte plant where a vibratory grate calciner is used in lime manufacture. Quicklime is supplied to chemical, metallurgical and construction industries as well as to a growing market in the waste treatment field. Limestone is supplied to The Manitoba Sugar Company, Limited from the Manitoba quarries.

The limestone quarry at Kananaskis is about seven miles west of the lime plant and provides kiln feed for

Table 3. Canadian lime industry, 1975

Company	Plant Location	Type of Quicklime
New Brunswick		
1. Havelock Lime Works Ltd.	Havelock	High-calcium
Quebec		
2. Dominion Lime Ltd.	Lime Ridge	High-calcium[2]
3. Domtar Chemicals Limited	Joliette	High-calcium[2]
4. Gulf Oil Canada Limited Shawinigan Chemical Division	Shawinigan	High-calcium[2]
5. Quebec Sugar Refinery[1]	St-Hilaire	High-calcium
Ontario		
6. The Algoma Steel Corporation Limited[1]	Sault Ste. Marie	High-calcium
7. Allied Chemical Canada, Ltd.[1]	Amherstburg	High-calcium
8. BeachviLime Limited[1]	Beachville	High-calcium
9. Canadian Gypsum Company, Limited	Guelph	Dolomitic[2]
10. Chromasco Limited[1]	Haley	Dolomitic
11. Domtar Chemicals Limited	Beachville	High-calcium[2]
	Hespeler	Dolomitic[2]
12. Reiss Lime Company of Canada, Limited	Spragge	High-calcium
13. The Steel Company of Canada, Limited (Stelco)	Ingersoll	High-calcium[2]
14. Steetley of Canada (Holdings) Limited	Dundas	Dolomitic
Manitoba		
15. The Manitoba Sugar Company, Limited[1]	Fort Garry	High-calcium
16. Steel Brothers Canada Ltd.	Spearhill[3]	High-calcium
	Fort Whyte	High-calcium and dolomitic
Alberta		
17. Canadian Sugar Factories Limited[1]	Taber	High-calcium
	Picture Butte	High-calcium
18. Steel Brothers Canada Ltd.	Kananaskis	High-calcium
19. Summit Lime Works Limited	Hazell	High-calcium and dolomitic
British Columbia		
20. Steel Brothers Canada Ltd.	Kamloops	High-calcium
21. Columbia Lime Products Limited	Fort Langley	High-calcium

Source: Mineral Development Sector, Department of Energy, Mines and Resources, Ottawa.
[1] Production for captive use. [2]Hydrated lime produced also. [3]To be replaced by new rotary kiln plant at Falconer by mid-1976.



the production of quicklime and hydrated lime. A second rotary kiln went on stream early in 1972, doubling the production capacity of the plant.

The new rotary kiln plant at Pavilion Lake, about 15 miles west of Cache Creek, went on stream in early 1975. It is equipped with the latest preheater design and will be capable of producing approximately 300 tons a day of high-calcium lime for the mining and forestry industries in the British Columbia interior.

Summit Lime Works Limited, near Crowsnest, produces high-calcium limestone for use at sugar refineries; dolomitic and high-calcium stone for metallurgical use and high-calcium quicklime and hydrated lime for the chemical, metallurgical and construction industries.

During 1971 Texada Lime Ltd. constructed a calcimatic-kiln lime plant at Fort Langley, British Columbia capable of producing up to 200 tons a day. Limestone is barged from Texada Island, and the product — a high-calcium quicklime — is marketed throughout the mining and pulp and paper producing regions of British Columbia. The plant went on stream in February 1972. MacDonald Consultants Ltd. of Vancouver, in partnership with M C Q Industries of Columbus, Ohio, were responsible for the design and development of the project. In late 1973 Texada Lime Ltd. was sold to Columbia Lime Products Limited.

Markets, outlook and trade

The metallurgical industry provides the largest single market for lime. With the increased application of the basic oxygen furnace (BOF) in the steel industry, lime consumption increased greatly in certain areas of the United States and Canada.

The pulp and paper industry is the second largest consumer of lime, most of which is used in the preparation of digesting liquor and in pulp bleaching. The decrease in lime production in 1975 can be attributed in great part to reduced activity in this sector where labour unrest caused prolonged work stoppages.

The uranium industry uses lime to control hydrogen-ion concentration during uranium extraction, to recover sodium carbonate and to neutralize waste sludge. In the production of beet sugar, lime is used to precipitate impurities from the sucrate. It is used also in the manufacture of many materials such as calcium carbide, calcium cyanamide, calcium chloride, fertilizers, insecticides, fungicides, pigments, glue, acetylene, precipitated calcium carbonate, calcium hydroxide, calcium sulphate, magnesia and magnesium metal.

Table 4. Canada, consumption of lime, quick and hydrated, 1973-74
(producers' shipments and quantities used by producers, by use)

	1973		1974^p	
	(short tons)	($000)	(short tons)	($000)
Chemical and metallurgical				
Iron and steel plants	674,043	9,866	748,154	13,526
Pulp mills	228,283	4,039	265,454	6,150
Nonferrous smelters	88,792	1,517	114,371	2,452
Sugar refineries	37,635	742	31,530	714
Cyanide and flotation mills	52,629	747	78,387	1,544
Water and sewage treatment	94,148	1,651	94,417	1,883
Uranium plants	49,293	757	53,865	961
Other industrial[1]	563,381	9,448	647,548	12,160
Construction				
Finishing lime	47,919	1,526	36,539	1,432
Manson's lime	25,713	531	28,962	802
Sand-lime brick	24,273	353	21,860	446
Agricultural	10,906	251	12,942	350
Road stabilization	15,299	332	9,636	238
Other uses	60,999	774	15,589	292
Total	1,973,313	32,534	2,159,254	42,950

Source: Statistics Canada.
[1]Includes glass works, fertilizer plants, tanneries and other miscellaneous industrial uses.
^{p}Preliminary.

The rapidly-growing concern for care and treatment of water supplies and the appeal for enforced antipollution measures should result in greater use of lime for water and sewage treatment. The removal of SO_2 from hydrocarbon fuels either during the burning procedure or from stack gases by either wet or dry scrubbing could necessitate the use of lime and will undoubtedly develop a major market for this commodity as SO_2 emission regulations are developed. Lime is effective, inexpensive, and can be regenerated in systems where the economics would so dictate. Paradoxically, the industry is itself caught up in the clean-up campaigns sponsored by various levels of government, particularly those efforts directed at dust removal.

Soil stabilization, especially for highways, offers a potential market for lime. However, not all soils have the physical and chemical characteristics to react properly with lime to provide a dry, impervious, cemented and stable roadbed. Hydrated lime added to asphalt hot-mix prevents the asphalt from stripping from the aggregate. This could become more important as new technologies relating to asphalt maintenance and repair are adopted and as the sources of good clean aggregate become scarce.

The use of lime-silica bricks, blocks, and slabs has not been as popular in Canada as in European countries although lightweight, cellular, insulating masonry forms have many features attractive to the building construction industry.

Table 5. World production of quicklime and hydrated lime, including dead-burned dolomite sold and used, 1973-74

Country	1973	1974^p
	(thousand short tons)	
U.S.S.R.	24,000^e	24,000^e
United States	21,090	21,606
Japan	13,024	12,362
West Germany	12,386	12,358
Poland	8,483	8,619
France	5,461	5,767
Belgium	3,770	3,940^e
East Germany	3,339	3,420^e
Romania	2,858	3,090^e
Czechoslovakia	2,904	2,910^e
Chile	–	2,862
Italy	2,478	2,540
Brazil	2,200^e	2,200^e
Canada	1,891	2,009
Other countries	14,313	13,878
Total	118,197	121,561

Sources: U.S. Bureau of Mines, Minerals Yearbook Preprint 1974; and Statistics Canada.
^{p}Preliminary; ^{e}Estimated; – Not applicable.

Although quicklime and hydrated lime are not of relatively high monetary value, they are transported considerable distances in bulk or in packages if a market exists. Freight costs can represent a large part of the consumer's cost. Production costs have been significantly increased as a result of higher energy costs. The industry, on average uses approximately 5.5 million BTU's per ton of production. New plants have incorporated preheater systems, and the need to replace some of the older, less efficient production capacity with fuel-conserving equipment is well recognized. The industry is aiming at a 14 per cent improvement in fuel utilization by 1980 over the base year of 1973.

Limestones are well distributed in Canada, but it does not necessarily follow that a lime-consuming industry will produce lime for captive use — lime producers will usually offer competitive prices. Nevertheless, some major users do produce lime for their own use and, especially in the United States in recent years, iron and steel producers have integrated backwards into lime manufacture. The complexities and inconsistencies of lime production and marketing are illustrated by the fact that Domtar, a Canadian company, operates a lime plant in Tacoma, Washington and in 1975 purchased a lime plant at Bellefonte, Pennsylvania from National Gypsum Company.

Canada is a net exporter of lime.

Prices

Quoted prices for both quicklime and hydrate vary greatly throughout the country, reflecting the costs of production and the influence of nearest competition. In Ontario, late-1975, prices for quicklime and hydrated lime were $24.25 and $24.75 respectively, bulk, fob works, carloads, per ton. By the first quarter of 1976 these had increased to $27.60 and $28.10.

Tariffs

Canada

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
29101-1	Lime	free	free	25%	free

United States

Item No.		Most Favoured Nation
512.11	Lime, hydrated	free
512.14	Lime, other	free

Sources: The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa. Tariff Schedules of the United States (Annotated), 1976. TC Publication 749.

Lithium

G.H.K. PEARSE

Lithium, having a specific gravity of 0.534, is the lightest element that is solid at ordinary temperatures. It is a soft, ductile, silvery-white metal that oxidizes rapidly in air and reacts readily with water. Lithium finds a diversity of specialized uses as mineral, industrial compound and metal. The principal ore minerals are spodumene, petalite, lepidolite and amblygonite occurring in pegmatite bodies.

Lithium deposits have been mined in the United States since 1889 and in Europe and Africa since the early 1900's. Lithium was used solely in a pharmaceutical preparation until near the end of the 19th century when it became important as an ingredient in special glasses. The Edison cell storage battery using lithium hydroxide was invented in 1908. Shortly after The First World War a hardened lead-base bearing alloy containing 0.04 per cent lithium was developed in Germany. Very little further research and development was done on lithium until The Second World War. During the war and continuing to the present, uses have multiplied dramatically, and consumption has increased more than twentyfold in the last 25 years.

Canada's only significant producer of lithium, Quebec Lithium Divisicn of Sullivan Mining Group Ltd., near Amos, Quebec, began production in 1955. The mine was closed in 1965 in the face of a strike and reduced markets and prices. A high-grade lithium zone at Tantalum Mining Corporation of Canada Limited's mine at Bernic Lake, Manitoba is being evaluated for possible future production.

Consumption of lithium products is increasing steadily under the stimulus of aggresive research and development by major producers in the United States. However, reserves of lithium in the United States, by far the world's principal consumer, are considerable; making access to that market from outside difficult.

Occurrences, production and developments in Canada

There are five known areas in Canada where substantial reserves of lithium occur. The Val d'Or — Amos area in northwestern Quebec, in which the Quebec Lithium mine is located, has been the principal producer. Numerous spodumene-bearing pegmatites occur in northwestern Ontario, principally in the Nipigon district. Small amounts of amblygonite and lepidolite have been produced in the Winnipeg River district of southeastern Manitoba since their discovery in 1924. More recently, in that area, Tantalum Mining Corporation of Canada Limited has delineated large reserves of spodumene ore at its Bernic Lake tantalum deposit. Several deposits have been explored in the Herb Lake area of northern Manitoba.

Amblygonite was recovered from two deposits in the Yellowknife — Beaulieu district, Northwest Territories, and small shipments were made between 1945 and 1955. Deposits in this district are currently considered too remote to be commercially viable.

Quebec. *Sullivan Mining Group Ltd., Quebec Lithium Division, Amos Mines Limited.* The Quebec Lithium property is underlain by numerous parallel pegmatite dykes trending easterly in a zone some 8,000 by 2,000 feet in the contact area between greenstones and granodiorite of the Lacorne batholith. Individual dykes are up to 2,000 feet long and 100 feet wide. Total reserves have not been made known by the company but are probably over 20 million tons, grading 1.2 per cent Li_2O. Plant start-up was in 1955. By 1957 a throughput of 1,000 tons of ore a day was achieved; the product being shipped to the United States under contract with Lithium Corporatoion of America. Upon cancellation of the contract, production was temporarily suspended in 1959 and resumed, at a reduced rate of about 250 tons a day, in 1960 to supply the newly built lithium chemical plant. A strike curtailed production in October 1965 and, in the face of dwindling markets and prices, management decided to close down operations and await more favourable developments in the industry. Stocks on hand were disposed of over the following two years. Total production from the mine was around 1 million tons of ore.

Other lithium properties of interest occur in the area.

Ontario. *Lithium deposits of the Nipigon district.* The first of numerous spodumene pegmatites southeast of

Lake Nipigon was discovered in 1955. Exploration activity which followed outlined several deposits with significant tonnages and grades. The principal property in the area is that of Big Nama Creek Mines Limited near Beardmore which is underlain by an *en echelon* dyke set totalling 2,800 feet in length and averaging 60 feet in width, and a parallel dyke to the south 800 by 60 feet. Diamond drilling to date has indicated 4.2 million tons grading 1.06 per cent Li_2O to a depth of 1,000 feet. Jean Lake Lithium Mines Limited and Ontario Lithium Company Limited have outlined 1.7 million tons grading 1.3 per cent, and 2 millions tons grading 1.09 per cent Li_2O, respectively. Other deposits of less than one million tons which carry values up to 2 per cent lithia occur in the district.

Development work done by Big Nama Creek Mines included the construction of a headframe, surface buildings, and the sinking of a shaft to 503 feet. Work was suspended in 1957. Renewed interest has been shown in the deposits by a European group, and metallurgical test work conducted by Lakefield Research was started in April 1975.

Other occurrences. Other properties of interest have been explored in northwestern Ontario; one in particular near Lac La Croix, about 70 miles east-southeast of Fort Frances, has an indicated 1.5 million tons grading 1.20 per cent lithia over a strike length of 1,600 feet to a depth of 500 feet.

Manitoba. *Tantalum Mining Corporation of Canada Limited, (Tanco) Bernic Lake.* Numerous complex, zoned pegmatites, bearing a variety of minerals, are known in the Cat Lake-Winnipeg River district of southeastern Manitoba. Tantalum Mining Corporation's deposit at Bernic Lake has the double distinction of being the world's largest tantalum deposit and the only known commercial deposit of pollucite, the principal source of cesium. A spodumene zone containing 5 million tons of 3 per cent Li_2O over a width of 30 feet occurs in the main pegmatite sill, and exploratory drilling underground penetrated a hitherto unknown spodumene-bearing sill beneath the present workings. The main zone is possibly the richest orebody of its kind in the world and the product is extremely low in iron and other impurities. A few tons of lepidolite were shipped from the Bernic Lake property prior to the mid-1950s.

A loan from the Manitoba Development Corporation was secured by Tantalum Mining Corporation in February 1972, for the construction of a pilot mill to produce spodumene concentrates. Trial shipments to customers during 1973 confirmed the product's suitability for ceramic purposes. In May 1974, Kawecki Berylco Industries Inc. of New York (KBI), acquired 24.9 per cent of Tanco. KBI, a major specialty metal producer, will assist in engineering feasibility studies for lithium production. The proposed facilities include a mill which will utilize heavy media and flotation for beneficiation, and a lithium chemicals plant. Planned annual output is 6,000 to 7,000 tons of Li_2CO_3 and a ceramic grade product of 1,000 tons of Li_2O equivalent (15,000 tons). A pilot lithium chemicals plant was built by KBI at Boyertown, Pennsylvania in 1975 to evaluate commercial production.

Several other occurrences in the Cat Lake — Winnipeg River district contain over 1 million tons of reserves grading 1.2 per cent or more lithia. Petalite, amblygonite, and other less-common lithium minerals occur, particularly at the east end of Bernic Lake. Beryllium, tin, columbium, tantalum, rare earths and other elements occur in the pegmatites of this area.

Herb Lake district. The two principal occurrences in the Herb Lake district of northern Manitoba contain 2 to 3 million tons of spodumene ore grading 1.2 to 1.4 per cent Li_2O.

Northwest Territories. Many lithium-bearing pegmatites are known in the Yellowknife-Beaulieu district of the Northwest Territories. There are reserves of several tens of millions of tons in the district, principally of spodumene ore, but also including significant tonnages of amblygonite. The remote location and lithium market conditions preclude exploitation of these deposits at present.

Other Canadian occurrences. Lithium pegmatites are known in several localities in the Appalachians, and two occurrences are reported from the Revelstoke district in British Columbia. These are currently of mineralogical interest only.

Uses

The unique physical and chemical properties of lithium and its compounds have given rise to a diversity of uses which continue to increase. The metal is employed in metallurgical applications as an alloy constituent and as a scavenger and deoxidizer of other metals. Lithium is the most electro-positive of the elements, which, with its light weight, makes it attractive as an anode material in batteries. This application is actively being explored and, within the last two years, several promising developments have been reported. The minerals lepidolite, petalite and spodumene find use as constituents in special glasses, ceramics, enamels and as welding and brazing fluxes. Lithium chemicals are used in the manufacture of lubricating greases, as a catalyst in numerous organic chemical processes, e.g., rubber and vitamin manufacture; as a dry chlorine vehicle for sanitation purposes and in pharmaceutical preparations. The use of lithium carbonate in aluminum production cells increases recovery, reduces power requirements and reduces fluorine gas emission. Growing acceptance of lithium carbonate by the aluminum industry has been the main factor in the increasing demand for lithium in recent years. Other lithium chemical applications include use in air conditioning, generation of oxygen and as an electrolyte in batteries.

World review

The United States is the world's principal producer and by far the greatest consumer of lithium products. Prior to the start of The Second World War production was little more than 100 tons of lithia (Li_2O) equivalent a year*. In 1975, world production was estimated to be 14,600 tons, more than two thirds of which was produced by the United States. This was a decrease of about 1800 tons resulting from a decline in demand.

Table 1. United States consumption of lithium[1], 1973

	1973
	(short tons Li_2O)
Aluminum production	3,000
Ceramics, glass	2,200
Grease	1,030
Air Conditioning	540
Welding, brazing	780[e]
Alloying, etc.	500[e]
Other	260[e]
Total[2]	8,300

Source: *Mineral Facts and Problems, 1975.*
[1]Figures converted to Li_2O equivalent. [2]Total rounded.
[e] Estimated by Mineral Development Sector.

All three producers in the United States also manufacture lithium chemicals. Foote Mineral Company mines spodumene at Kings Mountain, North Carolina and recovers lithium carbonate from brines at Silver Peak, Nevada. In May 1973, Foote opened a plant at Kings Mountain to produce low-iron spodumene by its recently developed thermal process. In March 1974 the company announced plans to construct a 6,000-ton-a-year lithium carbonate plant at Kings Mountain slated for start-up in 1976. The Silver Peak operation was expanded to 7,000 tons a year in late 1974. American Potash and Chemical Corporation recovers lithium carbonate from brines at Searles Lake, California. Lithium Corporation of America, a subsdiary of Gulf Resources & Chemical Corporation, mines spodumene at Bessemer City, North Carolina and plans recovery from Great Salt Lake near Ogden, Utah. Gulf's North Carolina chemical plant capacity is 13,500 tons of lithium carbonate a year.

The United States also imports lithium in the form of chemicals and minerals such as petalite and lepidolite for use in special glasses. Imports reached some 800 tons a year by 1967 and have since dropped to approximately 200 tons in 1974. Exports of contained lithia in products are about 2,000 tons a year.

Rhodesia was producing as much as 4,000 tons a year and was the primary supplier of United States import requirements until the United Nations embargo. Under this pressure, production tapered off to about 650 tons a year in 1972 and 1973. The sole producer, Bikita Minerals (Private) Ltd., closed its mine in 1974.

Other major producers include the U.S.S.R., the People's Republic of China and Southwest Africa. The U.S.S.R. is thought to have increased domestic consumption sharply over the last few years, especially for aluminum production. Approximately half of total exports of 1,400 tons to the western world has been shipped to Japan over the last few years and most of the remainder to Western Europe.

Table 2. World lithium production, 1973-1975

	1973[e]	1974[e]	1975[e]
	(short tons Li_2O)		
United States	10,700	11,900	10,700
Argentina	10	10	10
Australia	10	–	–
Brazil	300	320	170
People's Republic of China	700	700	580
Portugal	50	37	46
Southwest Africa	240	110	100
Rhodesia	650	210	–
U.S.S.R.	2,500	3,000	3,000
Total[1]	15,200	16,300	14,600

Sources: Various, including U.S. Bureau of Mines Commodity Data Summaries, January 1973 to 1975; Australian Bureau of Mineral Resources, Estatisticas Industriais (Portugal) and Minerals Development Sector estimates.
[1]Totals rounded [e]Estimated – Nil.

World reserves of lithium were estimated by the United States Bureau of Mines in 1974 to be about .7 million tons of contained lithium (1.5 million tons Li_2O), 327,000 tons of which occur in the United States. Total world reserves are more than adequate to meet anticipated requirements well into the 21st century.

Canada's reserves were estimated to be about 200,000 tons. More recent figures and the addition of reserves known in Ontario, the Northwest Territories and other localities in Manitoba, which were not included, raise known reserves to near 400,000 tons of contained lithium (1 million tons Li_2O).

Outlook

The lithium industry is small in comparison with other segments of the mining and chemical industries.

* Production and consumption figures given are short tons of Li_2O equivalent, except where otherwise indicated.

These figures can be converted to lithium metal equivalent by dividing by 2.153. Lithium carbonate figures can be converted to lithium metal equivalent by dividing by 5.323.

However, it has grown steadily since the end of The Second World War and continued growth at moderate rates is assured for the long-term. Annual consumption of lithium in the United States by the year 2000 was estimated to be between 17,700 and 66,000 tons based on projections made by the U.S. Bureau of Mines in 1975 (Its figures are given as 8,220 and 30,780 tons lithium metal equivalent).

Several breakthroughs is battery technology have been announced and the potential for battery use as a power source for automobiles and for peak power generation has become evident. One estimate for peak power installation requirements is an initial 5,400 tons of lithia. Annual requirements for electric automobiles could reach 30,000 tons by the turn of the century. World energy requirements will have to be met ultimately by thermonuclear reactors, the simplest form of which would utilize lithium, both as a heat transfer medium and a source of tritium for the reaction. The first practical plant is unlikely to be constructed until after the end of the century, but research requirements in this area may well expand significantly before that. The surge of lithium consumption in the United States during the 1950's, which peaked in 1959, was undoubtedly due to procurements for thermonuclear research. Consumption figures for this purpose are kept secret, but an estimate of over 7,000 tons between 1953 and 1959 seems likely. Fusion research uses may, therefore, easily exceed 1,000 tons a year during the 1990's. Given these developments, consumption in the United States could well exceed 50,000 tons a year by the year 2000.

During 1974 world lithium supplies were tight as a result of reduced exports from the U.S.S.R., closure of Bikita Minerals (Private) Ltd.'s mine in Rhodesia and increased demand in aluminum production. During 1975 demand dropped about 10 per cent. This is expected to be temporary and lithium demand is expected to resume at a healthy growth rate. Despite softened markets for aluminum, consumption of lithium in this industry should continue to increase as its use becomes more general. Expansion of lithium output capacity and new facilities scheduled for 1976 in the United States, and in the next few years in Canada, should raise world capacity by 40 per cent.

Magnesium

M.J. GAUVIN

Magnesium is found in naturally-occurring minerals such as dolomite, magnesite, brucite and olivine; in seawater, brines and evaporite deposits, and is consumed mostly in the form of nonmetallic compounds, principally magnesium refractories. Metal represents only about 10 per cent of consumption on a magnesium-content basis.

The metal is produced by two basic processes. The first is by electrolysis of magnesium chloride derived from seawater and brines. The second is a silicothermic process whereby magnesium ore, such as dolomite or magnesite, is mixed with ferrosilicon and reduced at high temperatures. All Canadian production is by the latter method, which is more suitable for smaller plants. The electrolytic method has risen to prominence because of large-scale plants utilizing low-cost electric power. Power requirements to produce magnesium electrolytically are 8-9 kWh per pound, even higher than the 7-8 kWh required to produce a pound of aluminum by the conventional Hall-Heroult process, and considerably higher than for the silicothermic process, including production of the ferrosilicon.

Canada

The only Canadian producer of primary magnesium is Chromasco Limited. This company has operated a mine and smelter at Haley, Ontario, 50 miles west of Ottawa since 1942.

A high-quality (98% pure) dolomite, low in impurities such as silica and the alkali metals, is mined from an open pit and calcined in a rotary kiln to produce dolime. Using the silicothermic (Pidgeon) process, dolime is mixed with ferrosilicon at a ratio of about 5 to 1. This mixture is charged in batches into retorts which are externally heated in furnaces, using natural gas as the main fuel. Under vacuum and at high temperature, the magnesium content is reduced and accumulated as crystalline rings known as "crowns" in the water-cooled head sections of the retorts. The plant has an annual capacity of 12,000 tons* of magnesium metal, but operated at less than 50 per cent capacity in 1975. A minor amount of this furnace capacity was used in the production of calcium.

The company produces ingots of magnesium metal in the following grades and purities: commercial, 99.90 per cent; high purity, 99.95 per cent and refined, 99.98 per cent. Magnesium alloys are produced to all specifications. Other magnesium products include master alloys, rods, bars, wire and structural shapes. The Pidgeon process is particularly suited for production of the purer forms.

To produce commercial-grade magnesium, the crowns are simply remelted and cast into ingots. This grade is suitable for general fabrication purposes and for alloying with aluminum, and represents the major proportion of production. The high-purity grade is mostly used for the formation of Grignard reagents (alkyl-magnesium-halides which react to form a variety of organic and inorganic compounds). The refined grade is in demand for chemical laboratory use and as a reducing agent for titanium, zirconium, uranium and beryllium.

Production of magnesium in 1975 was 4,961 tons, valued at $8,324,000 compared with 6,556 in 1974, valued at $9,260,172. In 1975, domestic consumption of magnesium was 5,609 tons, an 18 per cent decrease from the 6,852 tons consumed in 1974. The aluminum alloy industry was again the predominant outlet for magnesium, with the casting industry the next largest consumer of the metal.

Imports of magnesium metal and alloys were 9,241 tons in 1975 compared with the 8,249 tons imported in 1974. Exports of 4,152 tons of Canadian magnesium in 1975 were up from the 3,569 tons exported in 1974. Exports of magnesium metal have entered the United States duty free under the Canada-United States Defence Production Sharing Program which has recently been operating on a small scale. In the form of ingots, the United States tariff on magnesium is 20 per cent, whereas the comparable Canadian tariff is 5 per cent.

*The short ton of 2,000 pounds is used throughout unless otherwise stated.

Table 1. Canada, magnesium production and trade, 1974-75

	1974		1975p	
	(short tons)	($)	(short tons)	($)
Production[1] (metal)	6,556	9,260,172	4,961	8,324,000
Imports				
Magnesium metal				
United States	6,465	6,667,000	6,159	10,361,000
Netherlands	880	1,323,000	1,430	2,403,000
USSR	–	–	550	1,014,000
United Kingdom	18	73,000	114	192,000
Denmark	–	–	12	28,000
Other countries	76	122,000	–	–
Total	7,439	8,185,000	8,265	13,998,000
Magnesium alloy				
United States	557	910,000	518	1,192,000
Norway	–	–	260	445,000
United Kingdom	165	471,000	110	341,000
Italy	–	–	44	91,000
Switzerland	88	140,000	44	87,000
Total	810	1,521,000	976	2,156,000
Exports				
United States	608	2,439,000	1,771	4,273,000
United Kingdom	2,057	2,356,000	1,649	3,351,000
Netherlands	–	–	293	511,000
Switzerland	335	397,000	118	237,000
France	131	170,000	100	208,000
Hungary	–	–	81	173,000
Israel	55	151,000	48	151,000
Germany West	24	27,000	32	54,000
India	–	–	23	54,000
Brazil	143	114,000	12	43,000
Turkey	–	–	11	16,000
Australia	31	54,000	8	22,000
Uruguay	3	9,000	3	14,000
Argentina	20	27,000	2	9,000
New Zealand	–	–	1	3,000
Belgium-Luxembourg	1	2,000	–	–
Spain	4	11,000	–	–
Japan	135	169,000	–	–
Philippines	4	6,000	–	–
Leeward & Windward Islands	1	2,000	–	–
Colombia	17	26,000	–	–
Total	3,569	5,960,000	4,152	9,119,000

Source: Statistics Canada.
[1]Magnesium metal in all forms and in magnesium alloys produced for shipment, less remelt.
pPreliminary; – Nil.

Only in certain highly-pure items can the Canadian product find a market except under the Defence Production Sharing Program, or if the customer has a duty-drawback because of re-export.

World review

World production of primary magnesium in 1975 is estimated at 275,000 tons compared with 274,000 tons in 1974. The United States retained its dominant position, accounting for almost half of world production, followed by the U.S.S.R. and Norway. Secondary magnesium adds to the effective supply in some countries, notably the United States, which produced an estimated 20,000 tons of secondary metal in 1975, of which about 6,000 tons of the magnesium recycled was from old scrap. Japan's production of secondary metal in 1975 was 9,000 tons.

During the past 10 years, noncommunist world consumption has exceeded production. The market has been held in balance by sales from the United States government stockpile and exports from the U.S.S.R. During 1974, the General Service Administration completed the disposal of all magnesium metal in the government stockpile. Industry is now adding to capacity to supply an anticipated increase in world demand.

The world's largest producer is The Dow Chemical Company in the United States which has a capacity of 120,000 tons a year at its Freeport, Texas plant. Dow is expanding the capacity of this plant to 135,000 tons, with completion scheduled by 1978. Dow has also announced plans to construct by 1980 a new magnesium metal plant with a capacity of 50,000 tons a year.

N L Industries, Inc. started production from lake brines at its Rowley, Utah plant in 1972 and expected to have the plant producing at its designed capacity of 45,000 tons a year in 1975. However, the plant has been plagued with technical problems and in the last quarter of the year production was suspended except for technical evaluation purposes. Using outside consultants and a program of full-scale equipment testing, the company is aiming to have the plant operating profitably at a 25,000 ton a year level in 1977.

The electrolytic plant of American Magnesium Company at Snyder, Texas, has a capacity of 10,000 tons a year. The company is expanding its facility to 30,000 tons a year, and the work is expected to be completed in 1979.

Northwest Alloys, Inc., a subsidiary of the Aluminum Company of America (Alcoa), is building a magnesium plant at Addy, Washington. It will have an initial capacity of 24,000 tons a year, increasing to 40,000 tons in 1980. The plant is scheduled to begin producing magnesium early in 1976 and will use the Magnotherm process patented by Pechiney Ugine Kuhlmann Development, Inc. The plant will also produce ferrosilicon for use by Alcoa and other metal producers.

In Norway, Norsk Hydro-Elektrisk Kvaelstofaktieselskab plans to expand its plant at Heroya to 55,000 tons from 40,000 tons of magnesium output a year. The company also announced plans to construct and have in operation by 1980 a 50,000-ton-a-year magnesium plant at Mongstad, Norway. In Japan, Showa Denko Kahan Kaisha completed construction of a pilot plant with a capacity of 220 tons a year. The plant will test Showa Denko's new magnesium smelting process. Total Japanese production of primary and secondary magnesium amounted to 17,765 tons in 1975, 10.3 per cent less than in the previous year.

Technology

Technology is playing a large role in the growth of the magnesium industry. Two areas of technology have

Table 2. Canada, magnesium production, trade and consumption, 1965-75

	Production[1] Metal	Imports Alloys	Imports Metal	Exports Metal	Exports Metal	Consumption[2] Metal
	(short tons)	(short tons)		(short tons)	($)	(short tons)
1965	10,108	166	1,641	. .	4,456,255	4,499
1966	6,723	330	3,011	. .	3,452,000	5,137
1967	8,887	206	1,493	. .	3,696,000	5,054
1968	9,929	302	2,403	. .	4,261,000	5,654
1969	10,637	431	2,023	. .	4,726,000	5,672
1970	10,353	256	2,036	7,669	5,562,000	4,937
1971	7,234	152	1,827	2,917	2,227,000	6,276
1972	5,924	352	4,457	2,872	2,175,000	5,923
1973	6,840	556	5,050	3,562	3,025,000	7,293
1974	6,566	810	7,439	3,569	5,960,000	6,852
1975[p]	4,961	976	8,265	4,152	9,119,000	5,609

Source: Statistics Canada.
[1]Magnesium metal in all forms and in magnesium alloys produced for shipment, less remelt. [2]Consumption as reported by consumers.
[p]Preliminary; . . Not available.

Table 3. Canada, consumption of magnesium, 1965 and 1970-75

	1965	1970	1971	1972	1973	1974	1975^p
				(short tons)			
Castings[1]	512	850	1,316	1,110	1,001	1,283	1,058
Extrusions[2]	559	474	375	494	232	204	375
Aluminum alloys	2,959	3,123	3,972	3,924	4,317	3,975	2,870
Other uses[3]	468	490	613	395	1,743	1,390	1,306
Total	4,498	4,937	6,276	5,923	7,293	6,852	5,609

Source: Statistics Canada.
[1]Die, permanent mould and sand. [2]Structural shapes, tubing, forgings, sheet and plate.
[3]Cathodic protection, reducing agents, deoxidizers and other alloys.
^{p}Preliminary.

been growing side by side. The first is fluxless melting. To prevent melted magnesium from oxidizing, a heavy inert gas, sulphur hexafluoride (SF_6) is used in place of a flux. The second is the development of magnesium hot chamber, die-casting machines. Developed and first used in Europe, these machines are now being used in North America, together with an inert atmosphere for the casting of small parts, especially those having shapes that are difficult to cast. Cold-cast machines will continue to be used for large castings.

The third development is the use of magnesium as a desulphurizer in the steel industry. This application of magnesium is expected to account for the largest growth rate among the various uses for magnesium.

Uses

The major use of magnesium is in aluminum alloys where it provides hardness and strength. More magnesium is utilized in aluminum alloys than in magnesium alloys. Because of its high strength-to-weight ratio, magnesium is used in structural applications; i.e., those which involve load-carrying components. Although magnesium weighs only two thirds as much as aluminum, the latter metal can be substituted for magnesium in most structural applications, and a higher price has often placed magnesium at a disadvantage.

Typical structural uses of magnesium are in aircraft (particularly helicopters), missiles and space exploration vehicles, luggage frames, and materials-handling equipment such as gravity conveyors and hand trucks. Magnesium castings are used extensively in power lawnmowers, chain saws, typewriters and electronic equipment.

Non-structural applications, which have grown more quickly than structural uses, account for about 75 per cent of the consumption of magnesium. A rapidly-growing sector of this market is for aluminum alloy beverage cans which contain about 2.5 per cent magnesium. Other important non-structural uses of magnesium are as an alloying element for ductile iron, as a reducing agent in the production of titanium for cathodic protection, in the chemical industry for Grignard reagents, and an anti-knock fuel additive.

The use of magnesium as a desulphurizer in the manufacture of steel is a potential use in which no secondary material would be generated. This might result in sales of magnesium to the steel industry of up to 40,000 tons a year.

Table 4. World primary magnesium production

	1965	1974	1975^e
	(thousands of short tons)		
United States	81.4	133.0^e	134.0
U.S.S.R.	36.0	66.0	66.0
Norway	29.1	42.2	42.0
Japan	4.2	9.8	10.0
Italy	7.0	8.2	8.0
Canada	10.1	6.5	7.0
Other noncommunist countries	9.5	7.2	7.0
Other communist countries	1.0	1.1	1.0
Total	178.4	274.0	275.0

Source: Statistics Canada; Energy, Mines and Resources; U.S. Bureau of Mines.
^{e}Estimated; . . Not available.

Prices

The Canadian price of commercial grade magnesium, carload lots, fob Haley, Ontario was 91 cents a pound at the end of 1974. During 1975 it rose slightly in the first quarter of the year, then declined to 84 cents in July, which price was maintained for the balance of the year.

In the United States, the price per pound in 10,000-pound lots of 99.8 per cent metal, fob Freeport, Texas was 82 cents (U.S.) during 1975. The price of die-casting alloy AZ91B in the United States was 85 cents (U.S.) throughout the year.

Outlook

Aluminum alloying is expected to continue to be magnesium's most important market. Increasing usage of beverage cans and increasing emphasis on lighter weight transportation equipment are major applications for the growth of aluminum-magnesium alloys. The use of magnesium in the desulphurization of steel will provide new demand in the years to come. Traditional producers of magnesium are expected to be able to increase supply to satisfy increasing world demand.

Table 5. Estimated world primary magnesium capacity 1975

	Company	Location	Annual Capacity
Canada	Chromasco Limited	Haley, Ontario	12,000 (F)
France	Société Générale du Magnesium (Pechiney Group)	Marignac	9,900 (F)
Italy	Societe Italiana per il Magnesio e Leghe di Magnesio, Milan	Bolzano	12,000 (F)
Japan	Furukawa Magnesium Company	Koyama	7,200 (F)
	Ube Kosan K K	Yamaguchi	7,200 (F)
Norway	Norsk Hydro-Elektrisk Kvaelstofaktieselskab	Heroya, near Porsgrund	48,000 (E)
United States	The Dow Chemical Company	Freeport, Texas	120,000 (E)
	N L Industries, Inc.	Rowley, Utah	45,000 (E)
	American Magnesium Company	Snyder, Texas	10,000 (E)
U.S.S.R.	Various		65,000[e] (E)

Source: Société française de minerais & métaux, and various other sources.
Process: (F) Ferrosilicon; (E) Electrolytic.
[e] Estimated

Tariffs

Canada

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
		(%)	(%)	(%)	(%)
35105-1	Magnesium metal, not including alloys, in lumps, powders, ingots or blocks	5	5	25	3
34910-1	Alloys of magnesium, ingots, pigs, sheets, plates, strips, bars, rods and tubes	5	5	25	3
34915-1	Magnesium scrap	free	free	free	free
34920-1	Sheet or plate, of magnesium or alloys of magnesium, plain, corrugated, pebbled, or with a raised surface pattern, for use in Canadian manufactures (expires 31 October 1977)	free	free	25	free
34925-1	Extruded tubing, of magnesium or alloys of magnesium, having an outside diameter of five inches or more, for use in Canadian manufactures (expires 28 February, 1978)	free	free	25	free

Tariffs (concl'd)

United States

Item No.		On and After January 1, 1975
628.55	Magnesium, unwrought, other than alloys; and waste and scrap.	20%
628.57	Magnesium, unwrought alloys, per lb on Mg content	8¢
628.59	Magnesium metal, wrought, per lb on Mg content	6.5¢

Sources: For Canada, the Customs Tariff and Amendments, Revenue Canada, Customs and Excise Division, Ottawa. For United States, Tariff Schedules of the United States Annotated (1976), TC Publication 749.

Manganese

D.G. WEST

A world-wide downturn in steelmaking during 1975 led to a corresponding decline in manganese demand. Steel production in the major noncommunist countries was down 14 per cent from the previous year. The decline in demand for ferromanganese is expected to continue into 1976. High ferromanganese stocks and depressed demand led to slow manganese ore contract negotiations for the 1976 season.

Canada

Manganese and chromium are two important additives used in steelmaking that Canada does not produce. There are several low-grade manganese deposits which have been identified in Canada, but they are not economic and are therefore not mineable with current technology and ore prices. The United States also has similar low-grade manganese deposits. Research has developed the technology to utilize the low-grade manganese deposits, but not at a cost competitive with production from higher-grade deposits in other parts of the world. Low-grade manganese deposits have been identified in Nova Scotia, New Brunswick and British Columbia. A deposit near Woodstock, New Brunswick containing 50 million tons* grading 11 per cent manganese and 14 per cent iron is Canada's largest known manganese deposit.

There are two principal consumers of imported metallurgical-grade manganese ore in Canada; Union Carbide Canada Limited and Chromasco Limited. Both have plants at Beauharnois, Quebec where they produce ferromanganese for consumption by the major Canadian steel companies. A labour dispute at the Union Carbide plant began on January 19, 1975 and continued for seven months. However, the company continued operating at about 25 per cent capacity, and imported some 21,000 short tons of ferromanganese from the United States to help meet customer demand.

Manganese metal, which is an important additive in specialty steels and aluminum, must also be imported into Canada. Major consumers include Atlas Steels, a division of Rio Algom Limited; Aluminum Company of Canada, Limited, and Reynolds Aluminum Company of Canada Ltd. High-purity manganese dioxide is imported and used by Canadian Electrolytic Zinc Limited, Texasgulf Canada Ltd. and Cominco Ltd.

Most of the battery-grade manganese ores are imported for consumption by Ray-O-Vac Division of ESB Canada Limited, Mallory Battery Company of Canada Limited and Clerite Burgess.

Table 1 shows Canadian manganese trade and consumption.

World production and trade

In spite of unfavourable market conditions, world mine production of manganese ore is estimated to have risen to 24.8 million tons in 1975 from 24.2 million tons in 1974. World production for 1974 is shown in Table 3.

In Upper Volta, development of a 14-million-ton manganese deposit at Tambao continued during the year. The project includes production facilities of 688,000 tons per year (tpy) capacity and a 1,000-mile railway to Abidjan, a port of the Ivory Coast. Participants in the project include the Upper Volta government (51 per cent), a Japanese consortium (30 per cent), August Thyssen-Hutte AG (9 per cent), Union Carbide (7 per cent) and Societe du Manganese (3 per cent). Completion is scheduled in 1980-81.

South Africa continued to be the largest noncommunist producer of manganese ore. The greater part of production is mined in the Kuruman area of the Cape Province. Business mergers during the year resulted in the South African Iron and Steel Industrial Corporation Ltd. (ISCOR), a state-owned company, becoming the country's largest manganese and ferromanganese producer. Producers are increasing production as better transportation and ship loading facilities become available. Delta Manganese Proprietary, a producer of electrolytic manganese, is in the process of doubling its capacity to 31,000 tpy.

The Indian government has taken steps to ensure the country's supply of manganese ore by cutting back

*The short ton of 2,000 pounds is used throughout unless otherwise stated.

Table 1. Canada, manganese, trade and consumption, 1974-75

	1974		1975p	
	(short tons)	($)	(short tons)	($)
Imports				
Manganese in ores and concentrates[1]				
Gabon	40,356	3,706,000	41,365	5,254,000
Brazil	34,266	2,750,000	17,121	2,495,000
United States	35,867	2,732,000	10,251	1,471,000
Zaire	10,443	1,147,000	8,063	873,000
Other Countries[3]	16,970	1,255,000	61	6,000
Total	137,902	11,590,000	76,861	10,099,000
Manganese				
South Africa	3,337	1,785,000	5,415	3,689,000
West Germany	116	188,000	165	302,000
United States	630	469,000	200	251,000
Japan	188	168,000	150	206,000
France	—	—	12	19,000
Belgium-Luxembourg	66	108,000	—	—
Total	4,337	2,718,000	5,942	4,467,000
Ferromanganese, including spiegeleisen[2]				
United States	3,646	1,577,000	20,638	9,271,000
South Africa	9,450	2,204,000	5,608	2,857,000
France	5,674	1,416,000	4,282	1,775,000
Other countries[3]	95	70,000	8,844	2,718,000
Total	18,865	5,267,000	39,372	16,621,000
Silicomanganese including silico spiegeleisen[2]				
United States	471	180,000	6,318	3,230,000
South Africa	126	21,000	—	—
Total	597	201,000	6,318	3,230,000
Exports				
Ferromanganese[2]				
United States	11,068	2,938,000	1,209	210,000
Jamaica	148	47,000	78	32,000
Total	11,216	2,985,000	1,287	242,000
Consumption				
Manganese ore				
Metallurgical grade				
Battery and chemical grade	232,142		177,446	

Source: Statistics Canada.
[1]Mn content. [2]Gross weight. [3]Other countries include: Republic of South Africa, U.S.S.R., Mexico, Norway, Yugoslavia and Korea.
pPreliminary; — Nil; . . Not available

exports of medium grade ore and by banning the export of high grade ore (+45 per cent Mn).

Industria e Comercio de Minérios S.A. (IOCOMI) and the Brazilian government have agreed to limit exports of high-grade manganese ore to 1.3 million metric tons (tonnes) per year. Icomi is mining the Serra do Navio deposit which has enough ore reserves to last another ten years, IOCOMI had contracts for 1.6 million tonnes of manganese ore and pellets for 1975, however contract cancellations reduced deliveries to some 1.4 million tonnes. Cia. de Pesquisa de Recursos Minerais has reported an important manganese deposit in the State of Rondonia.

Australian production capacity of manganese ore ferromanganese and silicomanganese continued to expand during 1975. Production by Groote Eylandt Mining Company Proprietary Ltd., wholly-owned subsidiary of The Broken Hill Proprietary Company Limited (BHP), increased to 20 million tons per year with plans for further expansion to 2.2 million tpy in 1976. The Tasmanian Electro-Metallurgical Company, Ltd., also a BHP subsidiary, is doubling its production of ferromanganese by installing a third ferromanganese furnace and a manganese sinter plant. The company operations are at Bell Bay, Tasmania. At year-end Longreach Metals NL was trying to negotiate a long-term supply contract with Japan for 5.5 million tons of ferruginous manganese ore.

As is the case with some other manganese-producing countries, Gabon is in the midst of expanding production capacity. Construction of the Trans-Gabon railway, linking Moanda to the port of Libreville, is expected to be completed in 1981. Cie Minière de l'Ogooue will more than double its manganese ore production at Moanda once the rail line is complete. Proved reserves at Moanda are reported to be 495 million tons, which corresponds to 253 million tons of saleable material grading 50 to 52 per cent manganese dioxide.

With an annual output of 8.8 million tons, the U.S.S.R. is by far the world's largest manganese producer. Nearly 75 per cent is produced in the Nikopol Basin in the Ukraine. In 1975 Union Carbide signed a protocol with the U.S.S.R. and talks were held throughout the year on the construction of a one-million-ton-a-year ferromanganese plant. If a contract is signed Union Carbide will participate in design and construction, with 1980 being the expected completion date.

In 1975 as in past years the United States did not produce or ship manganese ore, concentrate or nodules containing more than 35 per cent manganese. In May of 1975 the United States Steel Corporation resumed ferromanganese production and during the balance of the year exceeded its 1974 output. Both Union Carbide Corporation and Foote Mineral Company cut their production rate for electrolytic metal by 50 per cent due to lack of demand.

Elsewhere: Yugoslavia is reported to be looking for a partner to develop a manganese deposit with proved reserves of 30 million tons; Japanese companies completed two 12,000 tpy electrolytic manganese dioxide plants in 1975 — one in Ireland (Mitsui), the other in Greece (Toyo Soda); a manganese centre has been established in Paris by producers and consumers; the new Ghana National Manganese Corporation, a crown company, experienced organizational problems and production was down in 1975; Hungarian production of manganese dioxide remained relatively unchanged in 1975 and no substantial increases of known reserves were discovered in the Urkut area; and Minera Autlen, Mexico's largest manganese producer, plans to double production capacity to 600,000 tpy by 1979.

The United States consumption of manganese ore is estimated to have risen to 1.9 million tons from 1.8 million tons in 1974, but that of ferromanganese declined to 900,000 tons from 1,115,000 tons. By year-end U.S. stocks of manganese ore were 1.9 million tons and ferromanganese stocks were 350,000 tons. General Services Administration (GSA) negotiated eight ore contracts in 1975, totalling 473,833 tons. U.S. steel production was down by 30 per cent in the last quarter, accounting for the decline in ferromanganese demand, which will probably continue into the next year.

Uses

More than 90 per cent of manganese consumed is used in the steel industry, where it is used primarily as a desulphurizer and as a deoxidizer. As an additional agent it hardens steel and reduces its plasticity.

In steelmaking furnaces, manganese is primarily added in the form of ferroalloys. The principal manganese ferroalloys are shown in Table 6. Some manganese is added as manganese metal, principally in the manufacture of specialty steel where adjustment of manganese content in the late stages of refining precludes the use of ferromanganese and its associated impurities. Some reduction in the amount of manganese ferroalloys required in steelmaking furnaces can be realized by adding manganiferous iron ores in the blast furnace. However, no empirical relationship has been developed to determine the precise savings. Current practice in Canada indicates that about 14 pounds of manganese are used in the production of one ingot ton of steel, exclusive of any manganese contained in iron ores charged to blast furnaces.

The property that makes manganese irreplaceable in steelmaking is its excellence as a desulphurizer. Steels which contain too much sulphur tend to crack or tear during rolling. Excess sulphur also tends to create surface imperfections during fabrication because the sulphur is usually not disseminated uniformly throughout the steel and, thus, creates a difference in properties in various parts of the steel. Manganese also has some deoxidizing power, but a number of other elements such as silicon have a greater affinity for

Table 2. Canada, manganese imports, exports and consumption, 1965-75

	Imports			Exports	Consumption	
	Manganese Ore[1]	Ferro-Manganese	Silico-Manganese	Ferro-Manganese	Ore	Ferromanganese and Silicomanganese
	(gross weight, short tons)					
1965	89,480	34,562	787	3,817	119,289	77,367
1966	184,103	49,118	1,931	5,722	152,536	84,922
1967	82,659	16,044	4,202	4,339	137,395	80,577
1968	69,209	27,941	1,344	1,018	124,904	93,374
1969	107,954	24,524	4,599	5,512	168,485	91,094
1970	126,823	19,721	1,075	562	169,586	107,974
1971	110,885	21,558	1,790	381	174,761	100,301
1972	98,177	18,895	16,637	2,278	183,175	102,049
1973	147,045	26,511	10,750	3,333	188,072	103,252
1974	137,902	18,865	597	11,216	232,142	104,414
1975^p	76,861	39,372	6,318	1,287	177,446	. .

Source: Statistics Canada.
[1]From 1964, Mn content, prior years gross weight.
^{p}Preliminary; . . Not available

Table 3. World production of manganese ores

	Mn^e	1972	1973	1974^p
	(per cent)	(thousands of short tons)		
Country				
U.S.S.R.	35	8,619	9,088	9,400^e
Republic of South Africa	30+	3,606	4,603	4,129
Gabon	50-53	2,135	2,115	2,357
Brazil	38-50	2,268	2,378	2,000^e
Australia	37-53	1,284	1,678	1,678
India	10-54	1,810	1,692	1,595
People's Republic of China	30+	1,100^e	1,100^e	1,100^e
Mexico	35+	326	401	444
Zaire	35-55	407	368	340
Ghana	32-50+	549	351	330^e
Morocco	53	106	161	193
Japan	27-45	287	208	184
Hungary	30−	170	150	155
Bulgaria	30−	33	42^e	44^e
New Hebrides	42-44	31	33	42
Thailand	46-50	22	40	32
Chile	41-47	18	16	32
Iran	33+	6^e	24	20^e
Other countries		171[1]	120[1]	100[1]
Total		22,948	24,568	24,175

Source: U.S. Bureau of Mines *Minerals Yearbook* Preprints, 1973 and 1974.
[1]Includes 19 countries, each producing less than 28,000 tons per year.
^{e}Estimated; ^{p}Preliminary.

oxygen. Any manganese oxide and manganese sulphide produced by these scavenging reactions form a fluid slag which is readily separable from the steel.

Manganese is also a common constituent of iron castings, where it is used to control the sulphur content since sulphur, if not neutralized by manganese, creates surface imperfections and areas of dissimilar properties in the iron and increases its shrinkage. This makes precise casting difficult. Manganese is added to specialty steels primarily to increase strength and/or reduce ductility. One group of alloy steels, known as Hadfield steels, contains 10 to 14 per cent manganese. Hadfield steels are extremely hard and tough and find their chief applications in parts subject to severe mechanical service conditions, such as rock crusher parts and teeth on excavating equipment.

Electrolytic manganese (99.8 per cent Mn) is used as a deoxidizing agent and as a constituent of nonferrous metals to improve their properties when a minimum of iron and carbon are desired; i.e., instead of manganese ferroalloys. As an alloying agent in nonferrous alloys, manganese improves the strength, ductility and hot-rolling properties. It is used as an alloying element and a cleanser in aluminum alloys, aluminum-bronze alloys, bronze alloys and nickel-chromium superalloys.

The most important use of manganese chemicals is in dry-cell batteries. A dry-cell battery consists of a zinc can, which acts as the anode, and a cathode material (the mix core) which consists of manganese dioxide, carbon and an aqueous electrolyte. The manganese dioxide-zinc cell may assume greater importance in the future. This cell can be made into small wafer types suitable for use in hearing aids and for incorporation into home appliances. Its principal advantage is its ability to work with high efficiency under high-drain conditions.

Manganese dioxide is also used as an oxidant in the processing of several minerals. It is used in some hydro-metallurgical processes for uranium, in the production of electrolytic zinc, to remove iron in magnesium refining, and in the recovery of noble metal values from copper refinery slimes. Manganese dioxide is also used as fluxes in welding rods.

Manganese chemicals have a small but widespread use in plating, as an oxidant and purifier of liquid organics to produce products for the pharmaceutical and chemical industries, in fertilizers, in the manufacture of dyes and pigments, as a drier in paint and as a catalyst in the synthetic fibre and plastics industry. Manganese chemicals are also used as colouring agents in glass and enamel products, ceramics, and cement and bricks.

Table 4. Principal manganese ferroalloys

	Manganese	Silicon	Carbon
	(per cent)		
Ferromanganese			
High-carbon	74-82	1.25 max.	7.5 max
Medium-carbon	74-85	1.50 max	1.5 max
Low-carbon	80-85	7.00 max	0.75 max
Silicomanganese	65-68	18-20 max	0.6-3.0
Spiegeleisen	16-28	1.0-4.5	0.65 max

Source: Mineral Development Sector, Department of Energy, Mines and Resources, Ottawa.

Prices

Manganese prices continued the steady increase that has been experienced in the past; however, 1975 prices may prove to be the peak for some time. Consumers are balking at the price increases demanded for 1976 contracts and the slump in steel production has given rise to large stockpiles of manganese ore and ferromanganese.

Outlook

In the short term, the manganese market will remain highly competitive and prices may weaken slightly. The recovery year of 1976 should lead to increased economic activity, with world demand for steelmaking material on the rise. Poor transportation facilities in some major producing countries may result in a shortage of high-grade manganese ore. This problem should be alleviated by the early 1980s.

In the United States manganese demand is expected to have an annual increase of 2 per cent through 1980. In the U.S.S.R. construction of a 1-million-tpy ferromanganese plant should not affect manganese ore demand or ferromanganese supply in the noncommunist world. In recent years the U.S.S.R. has not been active in the manganese market either buying or selling ore, or selling ferromanganese.

Several consortia are studying the potential of ocean mining of manganese nodules. The cost involved in this type of mining will most likely keep any production out of the competitive market into the next decade.

Four countries; Brazil, Australia, Gabon and the Republic of South Africa, control 75 per cent of the noncommunist manganese production. India, which produces most of the refining manganese, has recently banned export of high-grade ore. These four countries could control the market in high-grade manganese ore, and there appears to be some corporate agreement among them concerning prices. Therefore, barring a worsening slump in the steel industry, it is most likely that manganese prices will continue to rise.

United States prices in U.S. currency, published by Metals Week of December 1974 and December 1975.

	December 1974	December 1975
	(¢)	(¢)
Manganese ore, per long-ton unit (22.4 lb) cif U.S. ports, Mn content		
Min. 48% Mn (low impurities)	110.0-118.0	138.0-142.0
Ferromanganese, fob shipping point, freight equalized to nearest main producer, carload lots, lump, bulk per long ton of alloy	($)	($)
Standard 78% Mn	400.0	440.0
	(¢)	(¢)
Medium-carbon, per lb. Mn	37.5-49.0	41.5-49.0
Ferromanganese silicon	32.0	35.0
Silicomanganese, per lb. of alloy, fob shipping point, freight equalized to nearest main producer, carload lots, lump, bulk		
16-16½% Si, 2% C	21.5	24.0
Manganese metal, electrolytic metal, 99.9%, per lb. Mn, boxed fob shipping point		
Regular	54.00	54.0
6% N	57.0	57.0

Tariffs

Canada

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
			(¢)	(¢)	
32900-1	Manganese ore	free	free	free	free
33504-1	Manganese oxide	free	free	free	free
35104-1	Electrolytic manganese metal	free	free	20%	free
37501-1	Ferromanganese, spiegeleisen and other alloys of manganese and iron, not more than 1% Si, in the Mn content, per lb.	free	0.5	1.25	free
37502-1	Silicomanganese, silico spiegel and other alloys of manganese and iron more than 1% Si, on the Mn content per lb.	free	0.75	1.75	free

United States

Item No.		(¢ per lb on Mn content)
601.27	Manganese ore (duty temporarily suspended to end of June 1978)	0.12
607.35	Ferromanganese, not containing over 1% C	0.3 + 2% ad. val.
607.36	Ferromanganese, containing over 1% but not over 4% C	0.46
607.37	Ferromanganese, containing over 4% C	0.3
632.32	Manganese metal, unwrought, waste and scrap (duty temporarily suspended on waste and scrap to end of June 1978)	1.5¢ per lb + 10% ad. val.

Sources: The Custom Tariff and Amendments, Department of National Revenue Customs and Excise Division, Ottawa. Tariff Schedules of the United States, Annotated (1976), TC Publication 749.

Mercury

J.G. GEORGE

The Pinchi Lake mine of Cominco Ltd., some 30 miles north of Fort St. James, British Columbia, was again in 1975 the sole source of Canada's mine output of mercury until July 1975 when it suspended operations indefinitely. The closure was occasioned by the significant decline in mercury prices that began late in 1974 and continued in 1975. The drop in prices resulted from declining consumption and a world oversupply of the metal. From January 1, 1975 through to the time of closure of the property, the Pinchi Lake mill processed 125,000 tons* of cinnabar ore compared with 173,000 tons in 1974. Beneficiation of the ore involves concentrating it by flotation, then roasting the concentrate to produce mercury vapour which, in turn, is cooled and condensed to produce liquid metallic mercury. In 1975 the roaster produced 12,000 flasks** of refined mercury compared with 14,000 flasks in 1974. The Pinchi Lake mine's ore reserves at the end of 1975 were 1,200,000 tons containing 98,000 flasks of mercury compared with 1,300,000 tons of ore containing 110,000 flasks of mercury on December 31, 1974. From late 1968, when the mine was reopened, until its closure in 1975, refined mercury output totalled 122,760 flasks, with the greatest annual production being 24,400 flasks in 1970.

Cominco Ltd. also produced high-purity mercury metal with metallic impurities totalling ten parts per billion, or less, at its electronic materials plants at Trail, British Columbia. This specialty metal product was manufactured mainly for special applications in the electronics industry, such as advanced radiation detector materials.

Little exploration and development work was done in 1975 at Canadian mercury mining prospects because the demand for the metal continued to remain at relatively low levels.

Canadian imports of mercury metal in 1975, at 162,100 pounds (2,133 flasks), were substantially lower than the 239,900 pounds (3,157 flasks) imported in 1974. Partial consumption of mercury metal in Canada, as reported by Statistics Canada, was 83,304 pounds (1,096 flasks) in 1974; 1975 figures are not available.

World review

Estimated world mine production of mercury in 1975 was 259,850 flasks, only slightly less than the 262,286 flasks produced in 1974. Spain continued to be the world's largest mine producer of mercury and, together with Italy, accounted for over 32 per cent of the total output. The eight countries with the largest production, in declining order of output, were Spain, U.S.S.R., People's Republic of China, Italy, Mexico, Yugoslavia, Algeria and Canada.

According to preliminary statistics for 1975, both Spanish and Italian output of mercury were little changed from that of the previous year. On the other hand, United States production was more than triple that of 1974.

In Spain, the Minas de Almaden Company, whose Almaden mine is the largest mercury producer in the world, completed construction of a new plant at Almaden which uses a new process for treating waste residues from its roaster to yield an additional 5,000 to 10,000 flasks of mercury a year. The current stockpile of residues could reportedly provide an additional 200,000 to 300,000 flasks. The Almaden Company is reported to have found a new cinnabar deposit grading up to 37 per cent mercury, thus making it the world's richest known quicksilver deposit. It is located on the site of an old abandoned mercury mine about 10 miles north of the existing Almaden mine. The extent or size of the deposit is not yet known but it could be mined by open-pit methods. Exploration work on the property is continuing. Increased production could also come from Algeria where del Monego, an Italian company, was scheduled to bring on stream a new mercury extraction plant near Annaba. The U.S.S.R., which in 1975 maintained its position as the world's second largest producer, plans to build a large mercury mining and metallurgical complex near Magadan on the Chukota Peninsula, in eastern Siberia. Construction plans were

* The short ton of 2,000 pounds is used throughout unless otherwise stated.

** The flask containing 76 net pounds avoirdupois is used throughout.

reportedly authorized after discovery of a deposit of mercury in commercial quantities.

In Yugoslavia, the Bosnian mining enterprise, Srednobosanski Rudnici Uglija, will develop mercury deposits discovered over a five-square-mile area at Drazevici, near Srednje in the Ozren mountains. About $1 million has already been spent on prospecting work. The main mineral in the ore is cinnabar and it has been reported that the deposits contain some 300,000 metric tons, sufficient to support a ten-year mining operation. The ore has been estimated to grade between 0.35 and 9.0 per cent mercury, with a mean of about 1.4 per cent.

Primary production of mercury in Japan ceased at the end of September 1974 when the country's sole producer, Hokushin Mining, a subsidiary of Nippon Mining Co. Ltd., suspended operations at its Ryushoden mercury mine in Hokkaido.

Because of the relatively low prices that again obtained in 1975, production at most of the mercury mines in Mexico remained unprofitable and several small marginal producers ceased operations.

By late 1972 Chinese mercury was reported to be slowly moving into western markets, including the United States. Since then it is believed that increasing amounts of Russian, as well as Chinese, mercury have been sold to western countries. Such sales have had a depressing effect on the mercury market and prices. Because of the lower mercury prices these foreign sales could, however, have tapered off in the latter part of 1975.

United States mine output of mercury increased substantially in 1975 as a result of the new production from the McDermitt mercury property in northern Humboldt County, Nevada. Production began in mid-1975 and the mine will eventually have the capacity to produce refined mercury at a rate of 20,000 flasks a year. The property is being mined by open-pit methods and the ore is processed in a 700-ton-a-day concentrator with the flotation concentrate being furnaced in a system containing a multiple-hearth roaster equipped with emission control devices. Ore reserves have been reported to be in excess of 3,000,000 tons, grading 0.5 per cent mercury. The primary mineral is cinnabar (HgS), but an unusual feature of the deposit is that about 10 to 30 per cent of the cinnabar in the orebody has been replaced by an uncommon mercury mineral known as corderoite ($Hg_3S_2Cl_2$). The McDermitt mine is about 2,000 feet north of the Cordero mine which, along with adjacent properties, produced over 115,000 flasks of mercury from 1941 to 1970. Develop-

Table 1. Canadian mercury production, trade and consumption, 1974-75

	1974		1975p	
	(pounds)	($)	(pounds)	($)
Mine production	1,064,000	..	912,000	..
Imports (metal)				
United States	36,700	144,000	106,800	315,000
Netherlands	7,500	27,000	47,300	125,000
Spain	128,800	201,000	7,700	35,000
Sweden	–	–	200	9,000
United Kingdom	300	1,000	100	...
Mexico	30,400	114,000	–	–
Italy	21,300	77,000	–	–
Peru	7,800	29,000	–	–
Yugoslavia	6,500	23,000	–	–
Switzerland	600	1,000	–	–
Total	239,900	617,000	162,100	484,000
Consumption (metal)				
Heavy chemicals	60,357	..	36,809	..
Electrical apparatus	32,199r	..	31,776	..
Gold recovery	427	..	779	..
Miscellaneous	10,221	..	3,083	..
Total	103,204r	..	72,467	..

Source: Statistics Canada, except for mine production figures, which represent output by Cominco Ltd. as reported in its annual report.
p Preliminary; r Revised; .. Not available; – Nil; ... Amount is less than $500.

Table 2. Canadian mercury production, trade and consumption, 1966-75

	Production,	Imports		Exports,	Consumption,
	Metal	Metal	Salts	Metal	Metal
	(pounds)	(pounds)	($)	(pounds)	(pounds)
1966	—	404,600	..	..	171,588
1967	—	356,300	..	..	245,121
1968	430,160	197,900	..	..	327,939
1969	1,603,600	133,600	..	..	308,814
1970	1,854,400	153,300	..	..	340,558
1971	1,406,000	122,000	..	..	193,968
1972	1,112,412[r]	174,700	..	..	114,636
1973	950,000	106,200	..	..	72,663
1974	1,064,000	239,900	..	..	83,304
1975[p]	912,000	162,100	..	..	..

Source: Statistics Canada for all figures, with the exception of metal production statistics for 1968 to 1975 inclusive which were obtained directly from Cominco Ltd. and represent output from its Pinchi Lake mine in British Columbia.
[p] Preliminary; [r] Revised; — Nil; . . Not available.

ment costs to bring the new mine into production have been reported to be some $9.7 million. Placer Amex, Inc., a wholly-owned subsidiary of Placer Development Limited, has a 51 per cent interest in the McDermitt property, with Mineral Exploration Company of New Jersey holding the remaining 49 per cent interest. Noranda Mines Limited holds a 31.5 per cent direct interest in Placer Development Limited.

The United States is believed to be the world's largest consumer of mercury but has always produced less than its requirements. Total consumption in 1975 in the United States of primary, redistilled and secondary mercury was estimated at 51,105 flasks, a decrease of 14 per cent from the 59,479 flasks consumed in 1974. A large portion of the U.S. requirements was again derived from imports, which totalled 44,472 flasks* in 1975, a decline of almost 15 per cent from the 52,102 flasks imported in 1974. The largest suppliers in 1975, in declining order of amount supplied, were Canada, Algeria, Italy, Spain, Yugoslavia and Mexico. Together, these countries accounted for more than 92 per cent of total imports by the United States. Imports from Canada alone amounted to 12,891 flasks, or almost 30 per cent of the total.

The largest declines in United States mercury consumption in 1975 were noted in the metal's uses in electrical apparatus, industrial and control instruments, and in the electrolytic preparation of chlorine and caustic soda. The only upturn in demand occurred in mildew-proofing paints.

World consumption of mercury in 1975 is reported to have been about 250,000 flasks, or little changed from that of 1974. The lack of growth resulted partly because of the continuing public outcry against environ-

* Reported in United States, Department of the Interior, Bureau of Mines, *Mineral Industry Surveys*, "Mercury in the Fourth Quarter 1975".

Table 3. World production of mercury

	1971	1974[p]	1975[e]
		(flasks)	
Spain	50,831	60,200[e]	60,000
U.S.S.R.[e]	50,000	54,000	54,000
People's Republic of China[e]	26,000	26,000	26,000
Italy	42,613	24,950[e]	24,000
Mexico	35,390	21,200[e]	20,000
Yugoslavia	16,593	15,838	15,500
Algeria	7,136	13,300[e]	13,000
Canada[1]	18,500	14,000	12,000
Turkey	10,460	8,400[e]	..
Czechoslovakia	5,628	7,100[e]	..
United States	17,883	2,189	6,750
West Germany	2,030	4,930[e]	..
Peru	3,462	3,800[e]	..
Philippines	5,020	2,300[e]	..
Japan	5,564	1,409	..
Ireland	2,345	1,360[e]	..
Other countries	1,179	1,310[e]	28,600
Total	300,634	262,286	259,850

Sources: Preprint from the 1973 U.S. Bureau of Mines *Minerals Yearbook*, for 1971 statistics. U.S. Bureau of Mines, *Mineral Industry Surveys*, Mercury in the Third Quarter 1975, for 1974 statistics. U.S. Bureau of Mines *Commodity Data Summaries 1976*, for 1975 statistics.
[1] Output of Cominco Ltd. as reported by that company.
. . Date not available; [e] Estimate included in figure for "other countries".

mental pollution. In some large industrial nations, including the United States, the use of mercury in some of its applications continued to be adversely affected by this unfavourable publicity. One of the metal's two major uses, as a cathode in the electrolytic preparation of chlorine and caustic soda, continued to be a principal target of the ecologists because of the danger of pollution from the effluents. The danger of mercury poisoning has also continued to cut into other outlets for the metal, such as in agricultural, pulp and paper, and the paint industry.

For the past several years delegates from most of the major producing countries have held meetings in different countries at least once a year. The meetings have been producer oriented and one of the main items on the agenda has always been to try to bring about more stability to the mercury market, mainly by agreeing on concerted measures to control supplies and regulate prices. In April 1975 this group of world producers met again in Geneva, Switzerland and reportedly established the International Association of Mercury Producers (ASSIMER). The member countries of the new organization are Spain, Italy, Turkey, Yugoslavia, Algeria and Peru which together account for about 80 per cent of the noncommunist countries' exports of mercury. Most of the member governments control their countries' mercury production; only in Turkey is a form of private ownership allowed. ASSIMER'S headquarters are in Geneva. Among the objectives of the new association will undoubtedly be the stabilization of prices by curtailing production or withholding supplies from the market, the development of new uses for mercury and an improvement in its environmental image, and the promotion of the interests of the members of the association.

Table 4. United States mercury consumption, by uses, primary and secondary in origin

	1971	1974	1975p
	(flasks)		
Agriculture[1]	1,477	980	600
Catalysts	1,012	1,298	689
Dental preparations	2,361	3,024	1,773
Electrical apparatus	16,885	19,678	16,325
Electrolytic preparation of chlorine and caustic soda	12,154	16,897	15,223
General laboratory use	1,798	476	278
Industrial and control instruments	4,871	6,202	4,102
Paint:			
Antifouling	414	6	—
Mildew-proofing	8,191	6,807	6,926
Paper and pulp manufacture	2	—	—
Pharmaceuticals	682	597	431
Other[2]	2,407	2,452	1,735
Total known uses	52,254	58,417	51,105[3]
Unknown uses	3	1,062	..
Grand Total	52,257	59,479	51,105

Sources: Preprint from the 1973 U.S. Bureau of Mines *Minerals Yearbook*, for 1971 statistics. U.S. Bureau of Mines, *Mineral Industry Surveys*, "Mercury in the Second Quarter 1975", for 1974 statistics. U.S. Bureau of Mines, *Mineral Industry Surveys*, "Mercury in the Fourth Quarter 1975", for 1975 statistics.
[1] Includes fungicides and bactericides for industrial purposes.
[2] Includes mercury used for installation and expansion of chlorine and caustic soda plants. [3] The individual items do not add to the total which has been increased to cover approximate total consumption.

p Preliminary; — Nil; . . Not available.

At the end of 1975, United States government strategic stockpiles contained a total of 200,061 flasks of mercury, with no disposals from these stocks being made in that year. The strategic stockpile objective remained at the 42,700-flask level which had been established in April 1973. A bill, H.R. 7153, was introduced in the House of Representatives on April 18, 1973 to grant authorization for release of the total surplus of 157,361 flasks. The bill was referred to a subcommittee of the House Armed Services Committee but, as of December 31, 1975, no action had been taken by the Congress on the bill and, therefore, the proposed stockpile reduction and the rate of its disposal have yet to be determined. Such stocks are exclusive of excess mercury held by the United States Atomic Energy Commission (USAEC). In June 1969 these surplus USAEC stocks, which do not require Congressional authorization prior to being sold, were declared to be 15,000 flasks. Between then and the end of 1974, a total of 12,725 flasks were sold or released to other government agencies, leaving a surplus of 2,275 flasks of USAEC mercury available for disposal at December 31, 1974. General Services Administration (GSA) continued its offerings of such stocks in 1975 at the rate of 500 flasks (maximum) a month, with metal so released being restricted to domestic consumption. GSA released only 500 flasks in 1975, leaving a surplus of 1,775 flasks of USAEC mercury at December 31, 1975.

On July 10, 1975 the Commodity Exchange, Inc. of New York City (Comex) decided that trading in mercury futures would be suspended "indefinitely" when the only open contract, namely that for May 1976, was liquidated. Trading in mercury futures, which began on Comex January 16, 1967, was said to have been suspended because of a lack of interest on the part of investors. The Comex mercury contract was comprised of ten flasks of 76 lb each of mercury of not less than 99.9 per cent purity. Trading months were March, May, July, September or December within an 18-month period. Mercury futures are not traded on any other United States or Canadian commodity exchange.

World inventories of mercury held by producers have been rising and at the end of 1975 were estimated at 250,000 flasks. The combined total held by Spain and Italy alone was believed to be some 150,000 flasks. In the United States stocks of mercury held by producers increased from 4,102 flasks at the end of 1974 to 4,858 flasks at the end of 1975 and stocks held by consumers and dealers increased from 15,558 flasks at the end of 1974 to 22,702 flasks at the end of 1975.

In March 1974 the U.S. Environmental Protection Agency (EPA) promulgated its final effluent limitation guidelines for existing and new sources in the inorganic chemicals manufacturing category. The daily effluent limitation is 0.00028 pound of mercury per 1,000 pounds of product for mercury-cell plants in existence since March 1974. The limitation is 0.00014 pound of mercury per 1,000 pounds of product for new producing plants. One of the stated goals of the Federal Water Pollution Control Act of 1972 is the elimination of all pollutant discharges by 1985.

On April 6, 1973 the U.S. Environmental Protection Agency (EPA) published the final air emission standard for mercury at 5.1 pounds a day, per plant, released to the atmosphere. In 1974, EPA proposed an amendment to the emission standard for hazardous air pollutants in which mercury emissions from the incineration and drying of wastewater treatment plant sludges would be limited to a maximum of 3,200 grams (7.05 pounds) per day. Furthermore, the National Institute for Occupational Safety and Health submitted criteria for a recommended standard on the occupational exposure to inorganic mercury.

In October 1974 the Environmental Protection Agency opened hearings on the cancellation of biocidal uses of mercury, including mildewcides, in paint. The hearings were recessed until early in 1975 when they were held again, with witnesses for the registrants appearing. At further hearings in Washington in the second quarter of 1975, scientists representing private industry testified that micro-organisms de-methylated methylmercury, the principal organic mercury pollutant, into inorganic mercury and methane gas. They further stated that the de-methylation process was part of a natural mercury methylation-de-methylation cycle that has been occurring for millions of years. At year-end the issue had not been resolved.

In Canada, legislation, known as the "Chlor-Alkali Mercury Regulations" (P.C. 1972-576), was passed by the federal government March 28, 1972 and became effective 60 days after that date. This legislation restricted the quantity of mercury that may be discharged in the effluent from any chlor-alkali plant in Canada using the mercury-cell process. It stipulates that mercury in the liquid effluent, from any such chlor-alkali plant, deposited in any one day in waters frequented by fish shall not exceed 0.005 pound per ton of chlorine produced by the plant in that day.

Also in Canada, the Food and Drugs Act, a federal statute (Chapter F-27 R.S.C., 1970, as amended) is designed, among other things, to protect Canadians against health hazards related to foods. The Act is administered by the Health Protection Branch of the Department of National Health and Welfare. Section 4 (a) of the Act provides legal authority for the Branch to determine those levels in foods of substances such as mercury, which are considered to represent a hazard to human health, and prohibit the sale of foods containing unsafe levels of the substances in question. After a study of the available data on the toxic effects to humans of mercury-contaminated fish, the consumption of fish by Canadians, and action taken by other countries on this matter, the Health Protection Branch decided in 1969 that, as a temporary measure, it would take no exception to the sale of fish containing not more than 0.5 part per million (ppm) of mercury determined on a wet basis. In effect, this 0.5 ppm mercury level represents an administrative guideline applicable to fish only and legally binding only at the point of sale. Apparently this same 0.5 ppm mercury level in fish was subsequently adopted by the United States government authorities.

Outlook

Mercury prices declined through much of 1975 because of poor demand resulting from depressed world economic conditions, excessive stocks and substitution due to the adverse publicity from ecological sources. In the United States and Mexico several small, marginal mine producers of mercury suspended operations because of depressed world prices. Canada's sole producer at Pinchi Lake, B.C. was shut down for the same reason.

In 1976, mercury prices could strengthen somewhat, partly due to higher costs of production, but mainly because of the upturn in the United States economy and the anticipated improvement in the economies of Europe and Japan. Excessive worldwide stocks will, however, restrict any price increases to minor amounts. In the next few years mercury prices could again show distortions similar to those of the past because of erratic demand. Much will depend on the outcome of the efforts of the major producers to control offerings to the market and, hence, prices. There is also the risk that rising prices, if sustained for any period, might lead to the reopening of mines that cannot be operated economically under present conditions.

In addition to the high worldwide stocks held by producers and consumers, there is also overhanging the mercury market the substantial quantity of over 200, 000 flasks in the United States government's strategic stockpile. Another bearish factor is the possibility of increasing quantities of Russian and Chinese mercury being disposed of in Western Europe, but not in the United States because of higher import duties obtaining there against imports of mercury from communist countries. The market could also be faced with increased offerings from Turkey, because of new cinnabar discoveries and modernization of its existing mines, and from Algeria, where a new mercury extraction plant is expected to be built near Annaba.

Because of environmental factors, another negative influence on the mercury market in the medium term (up to 1980), will be the trend to greater use of the diaphragm cell (which requires no mercury) in the electrolysis of brine to produce chlorine and caustic soda. At present, more than two thirds of the chlorine produced in the United States is made in diaphragm cells, whereas in western Europe over 80 per cent is made in mercury cells. The mercury cell process for the electrolytic preparation of chlorine and caustic soda is currently one of the two major uses for mercury (the other being for electrical apparatus). While the short chlorine supply situation envisaged by the industry over the next few years will continue to spur expansion of chlor-alkali plants in the United States, none of the plants now under construction or on the drawing board will use the mercury cell. Also, some of the plants in the United States, Canada and Japan that were using the mercury cell have either dismantled their facilities or converted to the diaphragm cell. It is still the policy of the Japanese government to have all chlor-alkali plants in Japan using the mercury cell change over to the diaphragm cell process by March 1978. The excess secondary mercury released for recycling by such dismantled plants or those making the changeover has a further depressing effect on the market.

Although environmental problems will continue to check the growth in the overall use of mercury until about 1980, there is one bright spot in the outlook for the metal. Its consumption in the electrical apparatus industry is growing significantly and is likely to continue to do so for an indefinite period. Also, an increase in demand could eventually result from the concerted efforts expected to be made by the new mercury producers' association to find new uses and markets for the metal and its compounds. The development of improved antipollution technology could help the metal achieve a better image.

Uses

One of the oldest but now relatively unimportant applications of mercury is for recovering gold and silver from their ores by amalgamation. The two major uses in recent years have been for electrical apparatus and for the electrolytic production of chlorine and caustic soda. Together, these two uses accounted for over 60 per cent of mercury consumed in the United States in 1975. Electrical uses include mercury lamps, batteries, rectifier bulbs, oscillators, and various kinds of switches including "silent" switches for use in housing. Because mercury lamps are more adaptable to higher voltage supply lines than the lines used with incandescent lamps, they are used as fluorescent lamps, and for industrial and street lighting purposes. The mercury battery invented in 1944 is basically a dry-cell type battery. It has a relatively long shelf life and can withstand high temperature and high humidity. It is used in Geiger-Muller counters, portable radios and two-way communications equipment, digital computers, electronic measuring devices, hearing aids, guided missiles, and spacecraft.

Other applications are in mildew-proofing paints, industrial and control instruments, pharmaceuticals, insecticides, fungicides, bactericides, and dental preparations, although in some countries some of these uses have already been restricted or banned by governmental regulations. Several mercury compounds, especially chloride, oxide and sulphate, are good catalysts for many chemical reactions, including those involved in the making of plastics. Because of its capacity to absorb neutrons, the metal has been used as a shield against atomic radiation. One of the more recently developed applications for mercury is in frozen mercury patterns for manufacturing precision or investment castings. Here, mercury is superior to wax, wood or plastic materials because of its smooth surface and uniform expansion upon heating. New technologies could open up new areas of use in the nuclear, metal-chloride vapour, plastic, chemical, amalgam and ion exchange fields. Substitutes for mercury include nickel-cadmium or other battery systems for electrical apparatus, diaphragm cells for mercury cells in the chlor-alkali industry, organotin compounds in paints, and solid-state devices for industrial and control instruments.

Table 5. Average monthly prices of mercury in 1975 at New York and cif main European port

	New York[1]	Cif main European port[2]	
		Low	High
	($ U.S./flask)		
January	221.364	176.111	191.111
February	225.111	189.375	200.000
March	195.429	166.250	175.000
April	162.727	138.250	144.125
May	159.571	135.125	139.625
June	152.381	124.750	130.250
July	138.727	111.778	117.222
August	138.952	112.000	117.500
September	135.476	109.444	114.111
October	129.591	101.111	105.444
November	120.824	81.375	87.500
December	117.227	76.000	80.500

Sources: *Metals Week* for New York prices; *Metal Bulletin* (London) for cif main European port prices.
[1]Prime virgin metal. [2]Prices are cif main European port, min. 99.99 per cent.

Prices

Mercury prices displayed a downward trend throughout 1975 and toward the end of the year reached their lowest level in over 20 years. The price of mercury per flask, fob New York, as quoted in *Metals Week*, ranged between a high of $236 in February and a low of $117 in December. Average for the year was $158.12 a flask, compared with an average of $281.69 for 1974. In 1975, the cif main European port price, as quoted in *Metal Bulletin* (London), ranged between a high of $205 (U.S.) a flask in February and a low of $75 (U.S.) in December.

Tariffs

Canada

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
92805-2	Mercury metal	free	free	free	free
92828-4	Mercury oxide for manufacture of dry-cell batteries (expires February 28, 1977)	free	free	25%	free

United States

Item No.		Noncommunist countries	Communist countries except Yugoslavia
601-30	Mercury ore	free	free
632-34	Mercury metal, unwrought and waste and scrap	12.5 cents per pound	25 cents per pound

Sources: For Canada, the Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa. For United States, *Tariff Schedules of the United States Annotated (1976)*, TC Publication 749.

Molybdenum

MICHEL A. BOUCHER

In 1975, world molybdenum production and consumption were lower than in 1974, and at the end of the year producers had a three- to four-months' inventory. About 50 per cent of world production of molybdenum is a byproduct of copper mining, and copper production was lower in 1975 because of decreased demand resulting from the world economic slowdown. Likewise, consumption of molybdenum was lower because more than 80 per cent of all molybdenum is consumed by the steel industry. Tool steel and stainless steel production were particularly affected. A weak chemical market also contributed to a lower demand for molybdenum. Production of high-strength low-alloy steel (HSLA) was the only bright spot. Even though production and consumption of molybdenum was lower in 1975, prices of molybdenite concentrates, oxide, and ferromolybdenum increased by an average of 9 per cent. Non-Communist world production of molybdenite in 1975 is estimated at 160 million pounds of contained Mo compared with about 165 million pounds in 1974. Non-Communist world consumption for 1975 and 1974, respectively, were 155 and 190 million pounds.

The Canadian industry

Canadian shipments of molybdenum oxide, ferromolybdenum and sulphides in 1975 amounted to 27,414,000 pounds of contained Mo, valued at $68,893,000, compared with 30,736,353 pounds in 1974, valued at $61,778,008. Exports were 34,475,000 pounds, valued at $73,015,000 compared with 27,382,000 pounds, valued at $73,015,000 in 1974. Consumption was 3,688,655 pounds Mo content in 1974, the latest year for which statistics are available. Most molybdenum is consumed in Canada in the form of molybdic oxide and, to a smaller extent, as ferromolybdenum. Atlas Steels Division of Rio Algom Limited, The Steel Company of Canada, Limited and The Algoma Steel Corporation, Limited are the largest consumers.

Nearly 50 per cent of domestic molybdenum production comes from Endako Mines Division of Canex Placer Limited, Canada's only primary concentrate producer in 1975; the remainder comes from large-tonnage copper mines and is recovered as a byproduct of copper concentrating operations. Output in 1975 in terms of million pounds of molybdenum contained in concentrates was: Endako Mines Division of Canex Placer Limited 15; Brenda Mines Ltd. 8; Brynnor Mines Limited 2.5; Gaspé Copper Mines, Limited 0.5; Lornex Mining Corporation Ltd. 4.0; Utah Mines Ltd. 1.5; and minor production from Gibraltar Mines Ltd.

Noranda Sales Corporation Ltd. predicted molybdenite concentrate production for 1976, in millions of pounds of contained Mo, would be: Endako, 15; Brenda, 8; Brynnor, 2-2.5; Gaspé, 2.0; Lornex, 4.0; Utah, 1.8 and Gibraltar, again very small.

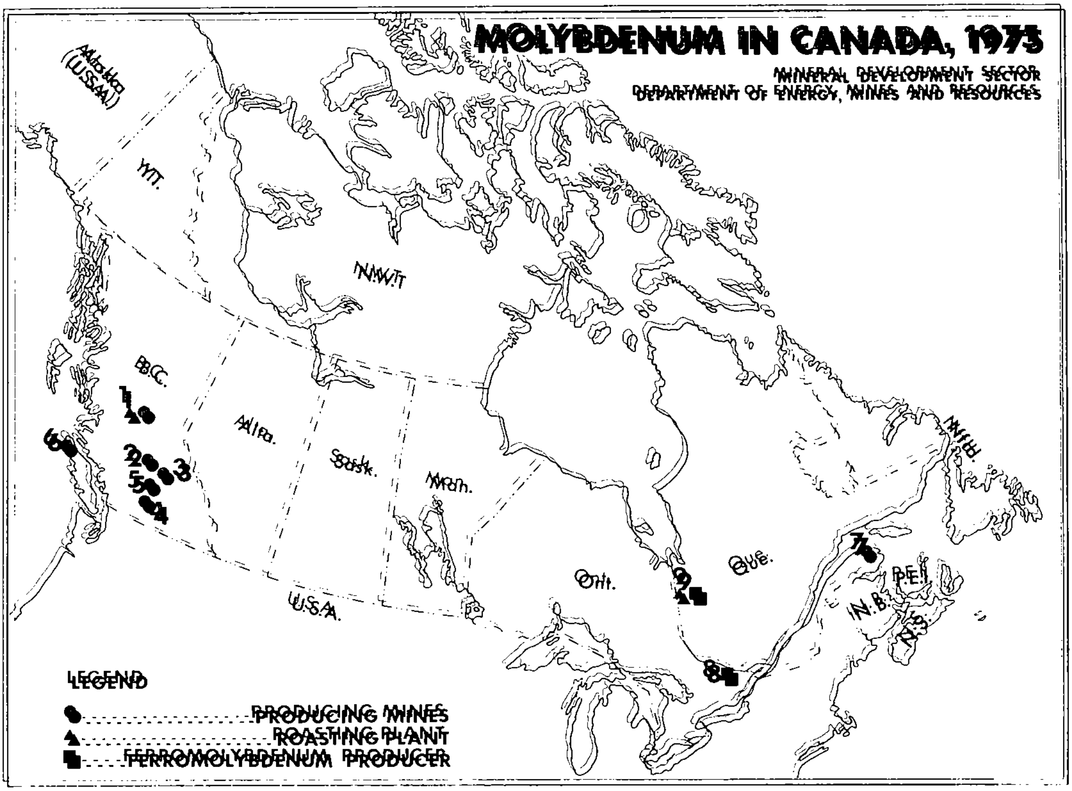
Canadian developments

Very little exploration for molybdenum was undertaken during 1975. Some companies attributed this to low incentives for mineral exploration.

Granby Mining Corporation continued its option on the Carmi porphyry molybdenum property of Vestor Explorations Ltd., near Kelowna, British Columbia, where drilling, has indicated continuous molybdenum mineralization over a surface area measuring about 1,100 feet by 250 feet. In the Northwest Territories, Dynamic Mining Explorations Ltd. and its partners in the Thelon-Dazan project expanded their holdings in the Baker Lake area. The property contains molybdenum and uranium.

The Boss Mountain molybdenite deposit of Brynnor Mines Limited was still being evaluated during 1975. Drilling is expected to be completed by the end of 1976. If large reserves are found, a much larger mill is planned than the present one, which can process 1,800 tons of ore a day. The possibility of a roasting operation is also envisaged. Canadian roasting capacity now stands at 25 million pounds a year of Mo contained in MoO_3 and is divided as follows; Endako 15 million pounds and Fundy Chemical International Ltd. 10 million pounds a year.

Noranda Metal Industries continued work at its research plant in Montreal on a chemical leaching process that would produce molybdic oxide directly (without roasting) and would also permit the recovery of rhenium. In Canada, rhenium is found in three



Producing Mines

(numbers refer to numbers on map)

1. Placer Development Limited (Endako)
2. Gibraltar Mines Ltd.
3. Brynnor Mines Limited (Boss Mountain)
4. Brenda Mines Ltd.
5. Lornex Mining Corporation Ltd.
6. Utah International Inc. (Island Copper Mines)
7. Gaspé Copper Mines, Limited

Processing Plants

1. Placer Development Limited (Endako Mine)
8. Masterloy Products Limited
9. Fundy Chemical International Limited

mines, Utah ore contains 2,000 ppm; Lornex 300 ppm; Brenda 80 ppm. Utah is the only mine where rhenium is recovered.

Two ferroalloy thermite furnace plants operated in Canada during 1975; Masterloy Products Limited near Ottawa, and Fundy Chemical International Ltd. at Duparquet, Quebec. Masterloy converted molybdic oxide into ferromolybdenum for Noranda and to a lesser extent for Continental Ore Corporation. Masterloy's annual production capacity is in the order of 3.5 million pounds Mo contained in Fe-Mo. Fundy Chemical roasted molybdenite concentrates to produce molybdic oxide. Fundy's molybdenite concentrates came from Noranda, from Climax Molybdenum Company in the United States and from Philipps Brothers, Division of Engelhard Minerals and Chemical Corporation, which obtains concentrates from Lornex, British Columbia and from Compania de Cobre Chuquicamata S.A. and El Teniente Mining Co., both in Chile. Fundy's annual ferromolybdenum capacity is about 1 million pounds Mo contained in Fe-Mo. Because of soft markets for molybdic oxide the plant will close during January and February 1976.

The Canadian market for chemical products such as molybdic oxide (chemical grade), ammonium molybdate and molybdenum disulphide (lubricant grade) is very small and there is no production in Canada. Because the domestic market is small, production would have to be export oriented. The major impediment to export of chemical products is the high tariffs imposed by the consuming countries. Tariffs increase as processing increases. For example, ore is usually imported duty free, while there is a tariff of about 8 per cent on oxide. Unwrought and wrought materials are protected by tariffs varying from 5 to 12.5 per cent.

World developments

In 1971 tunnelling work began at the Henderson mine of AMAX Inc. 50 miles west of Denver, Colorado, U.S.A. The mine contains reserves of over 300 million tons of ore grading 0.49 per cent MoS_2. Development costs before ore production begins in early 1977 will be close to $400 million. Mine production will start at a rate of 20 million pounds of contained Mo a year and output will be about 50 million pounds a year when capacity is reached in the early 1980's. This, combined with production from the Climax open-pit mine, will raise AMAX's total output to above 110 million pounds of contained Mo a year. Part of Henderson's output will be shipped to AMAX's roaster in the Netherlands and part will be treated at Fort Madison, Iowa.

Codelco's Chuquicamata molybdenum concentrator in Chile has been under construction for about three

Table 1. Canada, molybdenum production, trade and consumption, 1974-75

	1974		1975[p]	
	(pounds)	($)	(pounds)	($)
Production (shipments)[1]				
British Columbia	30,401,520	60,791,552	26,787,000	67,303,000
Quebec	334,833	986,456	627,000	1,590,000
Total	30,736,353	61,778,008	27,414,000	68,893,000
Exports				
Molybdenum in ores and concentrates and scrap[2]				
Belgium-Luxembourg	10,765,800	21,280,000	11,975,800	24,785,000
Japan	6,863,100	16,655,000	8,595,200	18,947,000
United Kingdom	2,552,000	4,883,000	4,811,600	9,712,000
West Germany	2,651,300	4,194,000	2,619,900	6,406,000
Netherlands	449,200	772,000	1,821,300	4,905,000
United States	396,500	393,000	2,631,500	4,019,000
Sweden	803,800	982,000	701,700	1,272,000
France	534,100	863,000	602,600	1,047,000
Brazil	724,400	1,602,000	264,600	615,000
Australia	409,000	981,000	139,700	453,000
Switzerland	—	—	125,300	361,000
Other countries	1,232,800	2,629,000	186,000	493,000
Total	27,382,000	55,234,000	34,475,200	73,015,000
Imports				
Molybdic oxide (gross weight)	189,400	268,000	140,100	257,000
Molybdenum in ores and concentrates[3] (Mo content)	2,229,757	4,232,509	1,157,499	2,717,085
Ferromolybdenum[3] (gross weight)	588,731	975,314	593,664	929,017
Consumption (Mo content)				
Ferrous and nonferrous alloys	3,491,481	. .	. .	. .
Electrical and electronics	13,284	. .	. .	. .
Other uses[4]	183,890	. .	. .	. .
Total	3,688,655	. .	. .	. .

Source: Statistics Canada, except where noted.
[1]Producers' shipments (Mo content) of molybdenum concentrates, molybdic oxide and ferromolybdenum. [2]Includes molybdenite, molybdic oxide in ores and concentrates. [3]United States exports of molybdenum to Canada, reported by the U.S. Bureau of Commerce, Exports of Domestic and Foreign Merchandise (Report 410), value in U.S. currency. These imports are not available separately in official Canadian trade statistics. [4]Chiefly pigment uses.
[p]Preliminary; . . Not available; — Nil.

Table 2. Canada, molybdenum production, trade and consumption, 1965-75

	Production[1]	Exports[2]	Imports		Consumption[5]
			Molybdic oxide[3]	Ferro-molybdenum[4]	
			(pounds)		
1965	9,557,191	. .	759,500	398,460	1,702,589
[illegible]	10,596,044	. .	665,500	522,800	1,261,387
1967	[illegible]	23,792,700	452,600	316,692	1,430,895
1968	[illegible]	22,704,500	1,359,300	284,600	1,543,432
1969	[illegible]	25,672,600	76,600	482,609	1,808,772
1970	[illegible]	30,334,000	73,900	65,299	2,286,061
1971	22,662,732	22,944,800	64,600	183,156	1,814,586
1972	28,493,007	31,329,300	26,700	74,201	2,708,059
1973	30,391,463	24,891,700	199,400	220,075	4,434,714
1974	30,736,353	27,382,000	189,400	588,731	3,688,655
1975^p	27,414,000	34,475,200	140,100	593,664	. .

Source: Statistics Canada.
[1]Producers' shipments (Mo content) molybdenum concentrates. oxide and ferromolybdenum. [2]Mo content, ores and concentrates, [3]Gross weight. [4]U.S. exports to Canada reported in United States Exports of Domestic and Foreign Merchandise, gross weight. [5]Mo content of molybdenum products reported by consumers.
^{p} Preliminary; . . Not available.

years. Upon completion of the new concentrator Chilean production of molybdenum in concentrates will be raised to some 25 million pounds a year, up from 20-22 million pounds a year.

Under a new agreement signed recently between the United States and a group of developing countries, the United States has exempted Chile from its 12¢-a-pound tariff on molybdenite concentrates. The new agreement will be effective January 1, 1976. Noranda and Canex Placer do not know yet to what extent their export sales will be affected by the agreement. Also, during the year Japan removed its tariff of 5 per cent on molybdic oxide.

In 1975 the stockpile of the U.S. General Services Administration (GSA) was exhausted of molybdenum in all its forms (molybdenum disulphide, molybdic oxide and ferromolybdenum).

Products [illegible]

[illegible] are the principal consumers of molybdenum, accounting for over 80 per cent of total consumption. The principal reason for the use of molybdenum in steel is that it increases strength, even at high temperatures, and increases resistance to corrosion. In low concentrations, molybdenum is used for tool steel. With concentration of 4 per cent, molybdenum is used for corrosion-resistant stainless steels, and with a concentration of up to 8.5 per cent it is used for high-speed tool steels. The remaining molybdenum consumption is used as catalysts in the petroleum and chemical industries to desulphurize petroleum products and chemicals, and as metal and base alloys in high-temperature applications, thermocouples, electronics, missile parts and structural parts of nuclear reactors. Molybdenum is also used in the production of pigments for inks, lacquers and paints. Between 60 and 70 per cent of Canadian and U.S. molybdenum consumption is in the form of molybdic oxide, 20-25 per cent in the form of ferromolybdenum and about 5 per cent as powder.

Table 3. Molybdenum production in ores and concentrates, 1973-75

	1973	1974	1975^e
	(Mo content, 000 pounds)		
United States	115,859	112,011	107,000
Canada	30,391	30,736	27,414
Chile	12,974	21,510	10,000
U.S.S.R.	18,700e	19,400e	. .
People's Republic of China	3,300e	3,300e	. .
Peru	1,591	1,650e	2,000
Bulgaria	310e	310e	. .
Japan	345	235	. .
South Korea	112	140e	. .
Mexico	90	90e	. .
Australia	2	25e	. .
Norway	448	—	. .
Other Freeworld	—	—	26,000
Total	184,122	189,407	172,414

Sources: U.S. Bureau of Mines, *Minerals Yearbook, 1974 preprint:* U.S. Commodity Data Summaries, January 1976; for Canada, Statistics, Canada.
^{e} Estimated; . . Not available; — Nil.

In 1975, molybdenum consumption continued to increase for use in high-strength low-alloy steels (HSLA) containing manganese, molybdenum and columbium. HSLA pipeline steel containing 0.3 per cent molybdenum and 0.052 per cent carbon can be welded under Arctic conditions which makes it applicable for use in pipelines under low-temperature conditions. Chromium molybdenum ferritic stainless steels containing 1-2 per cent molybdenum and 18-29 per cent chromium are growing in importance because of their excellent resistance to corrosion and attractive price.

The use of molybdenum in steels that resist abrasion is growing rapidly. Labour costs continue to rise sharply, and the cost of replacing worn parts in machinery that operates in abrasive environments also continues to rise proportionately. It therefore becomes more important to specify good wear-resistant materials even though first costs may be high. Molybdenum contributes to the abrasion resistance of these materials because of its influence on hardenability and carbide morphology.

Ore occurrences and grade

Molybdenum does not occur in the metallic form. Production is from deposits carrying the sulphide mineral molybdenite, MoS_2; other molybdenum-bearing minerals are relatively rare and of minor importance. About 60 per cent of world production of molybdenum comes from mines where molybdenite is the principal mineral produced. Most of the balance comes as a byproduct or coproduct from copper-molybdenum mining operations; some come from tungsten-molybdenum mines, and a minor amount comes from molybdenum-bearing uranium ores.

Molybdenite (MoS_2) contains 60 per cent molybdenum (Mo) but the content of mineable ores is generally relatively low, ranging down from 0.05 per cent MoS_2, or 0.6 pounds of Mo per ton, to about 0.15 per cent MoS_2, or 1.8 pounds of Mo per ton, among producers whose principal or only product is molybdenite, to as low as 0.015 per cent MoS_2 in some copper-molybdenum deposits now being prepared for production of both metals. A few small, vein-type deposits have limited ore zones with one or two per cent MoS_2.

Table 4. United States consumption of molybdenum by end use, 1974

(000 pounds contained molybdenum)	
Carbon steel	1,894
Stainless and heat resisting	10,043
Full alloys[1]	24,502
High-strength, low-alloy	3,108
Electric	584
Tool steel	5,080
Cast irons	4,666
Superalloys	3,595
Welding and hardfacing rod and materials	389
Other alloys and nonferrous alloys	646
Mill products made from metal powder	3,031
Chemical and ceramic uses	
Pigments	1,236
Catalysts	1,952
Other	1,285
Miscellaneous and unspecified	1,465
Total	63,476

Source: United States Bureau of Mines *Minerals Yearbook, 1974 Preprint.*

[1]A steel in which the maximum of the range given for the content of alloying elements exceeds one or more of the following limits: Mn 1.65 per cent; Si 0.60 per cent; Cu 0.60 per cent.

Prices

During 1975 the price of molybdenite concentrates was raised from $2.43 a pound of Mo contained to $2.62. Molybdic oxide was raised from $2.69 to $2.90 and ferromolybdenum from $2.98 to $3.50.

Outlook

Production and consumption should increase in 1976 owing to the expected recovery of the world economy. It is forecast that production will reach 180 million pounds while consumption will be about 175 million pounds. A further increase of perhaps 10 per cent for molybdenum products is also forecast for 1976 because of the high costs associated with the development of the Henderson mine in Colorado and higher general costs of production, which Amax, the mine owner and world price setter for molybdenum products, will have to pass on to its customers.

Prices in U.S. dollars a pound of contained molybdenum, fob shipping point, as reported in Metals Week.

	Dec. 30, 1974	Dec. 29, 1975
	($ U.S.)	($ U.S.)
Molybdenum concentrates Guaranteed Mn 85% MoS_2	2.43	2.62
Molybdic oxide (MoO_3) in cans	2.69	2.90
Ferromolybdenum, 0.12-0.25% C 5,000 lb lots		
Lump	3.25	3.44
Powder	3.19	3.50

Table 5. Tariff profile (most favoured nation)

Item	European Economic Community	United States	Japan (GATT)	Canada
Molybdenum ore and concentrate	Free	12¢ per lb on Mo content		Free
A. Quota			Free	
B. Other			7.5%	
Molybdenum oxides and hydroxides	8%	10¢ per lb on Mo content + 3%	Free	15%
1) Molybdenum & oxide				
2) Other				
Ferromolybdenum	7%	10¢ per lb on Mo content + 3%	6%	5%
Sodium molybdate	11.2%	5%	7.5%	15%
Ammonium molybdate	11.2%	10¢ per lb on Mo content + 3%	7.5%	15%
Cobalt molybdate	11.2%	10¢ per lb on Mo content + 3%	7.5%	15%
Molybdenum				
1) Unwrought: powder	6%	10¢ per lb on Mo content + 3%	5%	Free
other	5%	10¢ per lb on Mo content + 3%	5%	Free
Waste and scrap		10.5%	5%	Free
2) Wrought		12.5%	7.5%	Free
Bars, angles, plates, sheets	8%	12.5%	7.5%	Free
Wire	8%	12.5%	7.5%	Free
3) Other	10%	12.5%	7.5%	Free
Molybdenum carbide	9.6%	8%	5%	5%

Source: Mineral Development Sector, Department of Energy, Mines and Resources, Ottawa.

Natural Gas

W.G. LUGG

Although the growth rate of Canada's natural gas industry did not keep pace with that of the decade prior to 1973, most sectors enjoyed a relatively good year. Despite only marginal production increases, revenues from the sale of crude oil, natural gas liquids and natural gas reached an all-time high of $5,823 million. The large revenue increase relates to the July 1 rise in the posted price of crude oil as well as substantial increases in the price of natural gas. Netback to producers increased to a lesser degree as increased royalty payments and taxes absorbed a large part of the production revenue increase. Expenditures for exploration and development increased, but at a reduced rate from the previous year. Total expenditures in 1975 were $4,345 million, compared with $3,319 million in 1974; most of the expenditures were made in western Canada.

Net reservoir withdrawals rose by only 1 per cent to 3,086,792 MMcf or 8,457 MMcf/d*. All of the gain was assigned to the domestic market as exports to the United States declined from the previous year. Canadian consumers used 1,324,705 MMcf, or 3,629 MMcf/d, for a gain of 1 per cent from the previous year, and exports to the United States decreased by 1 per cent to 946,791 MMcf or 2,593 MMcf/d. Imports from the United States, never very large, remained at about the same level as in 1974, averaging 28 MMcf/d.

Gross additions to marketable reserves were only up slightly in 1975, notwithstanding the inclusion of substantial volumes of gas in Alberta formerly considered to be beyond economic reach. By the end of 1975 natural gas reserves had risen to 57 tcf**, 266,000 MMcf higher than in 1974.

Aggregate exploratory drilling footage, which includes both oil and gas wells was down 5 per cent from 1975. Nevertheless, exploratory drilling for natural gas was up substantially, at the expense of oil exploration. Three significant discoveries were made in Alberta, one of which may develop into a major field. Elsewhere, there was one significant new discovery in the Mackenzie delta and two major extensions to existing gas fields in the Arctic islands. In the offshore east coast area, the success attained in 1974 apparently was not maintained in 1975, although there were indications that two wells drilled late in the year had encountered significant occurrences of hydrocarbons. The full potential of these discoveries will await further evaluation during the limited drilling season in the summer of 1976.

Pipeline construction again decreased in 1975 and most of the decline was recorded in the large-diameter category. In regard to proposed northern pipeline construction, hearings conducted by the National Energy Board (NEB) on two opposing applications to construct a northern pipeline were still in progress and likely to continue well into 1976. The proposals being considered were submitted by Canadian Arctic Gas Study Limited (CAGSL) and Foothills Pipe Lines Ltd. Gas plant construction continued at a subdued pace in 1975 with little likelihood of any new major plants being built before 1978.

Outlook

The outlook for Canadian natural gas is a mixed one. In the long-term the industry's future depends on its ability to discover and develop commercial quantities of gas in the frontier areas. Exploration in these areas was disappointing in 1975 as only one significant gas discovery was made. There were, however, two major extensions to existing fields on Melville Island in the Arctic Archipelago. Both of these are now classified in the major field category, with their ultimate limits still to be determined. Several potentially significant exploratory wells were scheduled for the winter of 1975-76 in both the Mackenzie delta and the Arctic islands. The results of this drilling should provide an insight into the true potential of these regions.

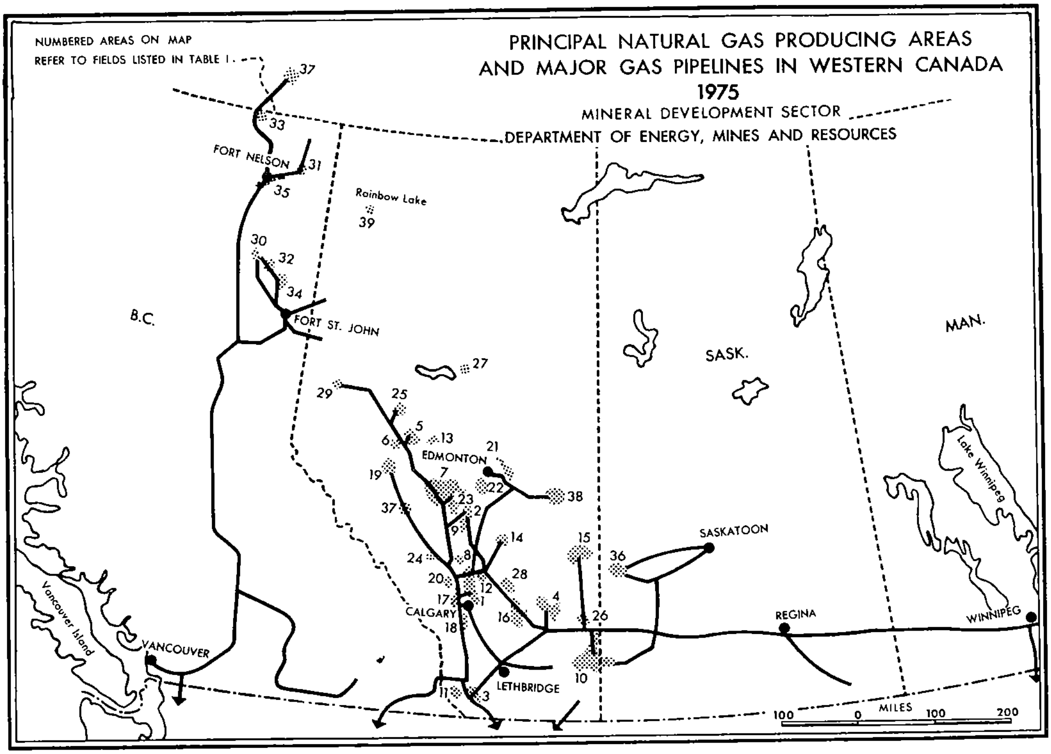
In the near-term the supply of natural gas for Canadian customers appears to be adequate. Since general agreement was reached on a more realistic

*MMcf/d = 1,000,000 cubic feet a day
**tcf = Trillion cubic feet.

Table 1. Canadian natural gas fields producing 10 million Mcf[1] or more, 1974-75[2]

(numbers in brackets refer to map locations)	1974 Mcf	1975 Mcf
Alberta		
Kaybob South (25)	262,667,175	249,484,187
Waterton (11)	132,934,133	142,860,103
Crossfield (1)	140,809,035	140,225,670
Edson (19)	116,191,565	105,563,104
Strachan (24)	109,680,237	97,598,770
Ricinus West (24)	92,129,210	85,275,647
Westerose South (2)	81,934,282	80,193,712
Medicine Hat (10)	78,865,302	98,790,995
Brazeau River (37)	76,691,176	77,542,320
Harmattan Elkton (8)	69,119,285	70,880,361
Harmattan East (8)	68,752,677	64,568,993
Dunvegan	44,383,784	51,322,015
Homeglen-Rimbey (9)	50,271,278	49,399,399
Carstairs (12)	52,116,846	48,517,493
Gilby (9)	48,319,967	47,593,810
Crossfield East (1)	42,526,812	45,124,834
Nevis (14)	40,059,671	44,729,456
Jumping Pound West (17)	42,764,350	42,810,264
Marten Hills (27)	32,894,237	40,189,470
Provost (15)	38,800,429	40,088,928
Windfall (5)	34,690,609	35,371,867
Cessford (4)	38,743,010	35,151,343
Minnehik-Buck Lake (23)	33,927,968	35,075,191
Wildcat Hills (20)	33,690,218	34,842,813
Pembina (7)	37,108,415	33,457,679
Ferrier (8)	34,499,175	33,179,288
Sylvan Lake (2)	25,819,018	31,234,023
Bonnie Glen (22)	22,274,707	29,081,770
Alderson (10)	28,681,565	28,922,112
Lone Pine Creek (1)	25,820,478	26,259,670
Pine Creek (6)	24,244,933	25,557,786
Viking Kinsella (38)	29,729,013	25,923,670
Swan Hills (13)	24,679,215	25,421,650
Judy Creek (13)	30,868,041	24,682,773
Kaybob (25)	27,925,530	24,570,952
Rainbow (39)	28,433,527	23,623,753
Swan Hills South (13)	15,830,554	22,119,559
Ricinus	18,071,809	21,766,833
Westlock (21)	25,233,396	21,319,045
Ghost Pine (28)	23,787,554	21,122,967
Quirk Creek	22,525,324	21,033,575
Carson Creek (13)	10,430,285	19,490,459
Burnt Timber (20)	14,926,521	19,278,563
Lookout Butte (3)	18,757,947	16,790,966
Bantry	11,728,432	16,637,549
Jumping Pound (17)	17,924,664	16,173,772
Beaverhill Lake	16,456,574	16,067,037
Wimborne (12)	14,083,326	15,889,243
Warwick	12,863,687	15,197,323
Hussar (16)	16,238,009	14,390,458
Fort Saskatchewan (21)	13,940,864	13,279,663
Leduc-Woodbend (22)	13,405,612	13,207,648
Bindloss (26)	13,511,945	12,631,651
Bruce	10,266,972	11,911,499
Olds (12)	11,886,044	11,062,615
Medicine River	9,184,430	11,067,562
Countess (16)	12,674,741	11,032,858
Carson Creek North (13)	11,998,485	10,964,291
Wayne-Rosedale (3)	11,674,311	10,748,303
Whitecourt	11,381,196	10,743,857
Bigstone (25)	12,526,586	10,678,918
Simonette	12,408,017	10,428,782
Craigend (27)	11,347,956	10,139,995
Wizard Lake	12,250,279	10,077,148
Caroline	10,525,506	9,842,449
Fairydell Bon Accord	10,782,760	9,545,082
Greencourt	11,258,510	9,089,198
British Columbia		
Clarke Lake (35)	105,752,430	97,900,513
Yoyo (31)	74,661,386	66,839,606
Sierra (31)	22,769,008	34,968,624
Laprise Creek (30)	26,117,394	25,994,959
Rigel (34)	20,217,583	17,876,942
Buick Creek (32)	14,103,027	13,779,441
Jedney (30)	11,907,682	12,832,070
Stoddart (34)	12,550,739	11,071,898
Beaver River (33)	16,203,477	10,975,147
Nig Creek (32)	13,225,693	10,436,018
Siphon	11,352,760	7,984,590
Northwest Territories		
Pointed Mountain (37)	32,010,480	30,890,747

Source: Provincial government reports.
[1]Mcf — 1,000 cubic feet. [2]14.65 pounds per square inch absolute.



market value of gas in relation to other energy sources in 1975 by the provinces, prices have been substantially increased. Therefore, it is now likely that adequate supplies will be available to meet projected demand growth in the domestic market from existing supplies for the next two or three years. In addition, the new price schedule has provided incentives for stepped-up exploration for gas in western Canada and this factor should tend to alleviate shortages. Supplies for export demand, however, will likely remain at 1975 levels or experience a slight decline as happened in 1975.

In summary, a 10 per cent annual growth rate that characterized natural gas production prior to 1975 can no longer be sustained from existing supplier sources. Domestic production is expected to increase by only about 2 per cent in 1976 to 8,625 MMcf/d, this trend could continue to 1980. At that time production will likely depend on the availability of new-found supplies from frontier sources.

Exploration and development

Alberta. The number of wells completed increased slightly in 1975, although footage drilled experienced a small decline. Aggregate drilling decreased by approximately 1 per cent to 11.9 million feet, as a slight increase in development drilling was more than offset by a decline in exploratory drilling. Overall drilling statistics reflect a decline in oil exploration and development work and an increase in natural gas work. The resurgence in exploratory and development drilling for gas in 1975 is shown in the statistics in Table 6. Drilling for gas increased by 239 wells to 1,958 in 1975. The increase in the number of completions compared to the reduction in footage is indicative of industry's continuing interest in the shallow gas prospects of southern Alberta as well as newly emerging interests in the northern part of the province. There also has been a return to drilling in the foothills, where at year-end more than 30 tests were underway. Recent drilling in this area has been highly successful and this factor, coupled with improving natural gas prices, has set the stage for renewed drilling there.

[illegible]

[illegible] Timber field, Shell Canada [illegible] made three gas discoveries. Two of these were recorded in the Willson Creek area — the first flowed gas from two zones below 8,400 feet at 4.4 MMcf/d and 9.7 MMcf/d. The second, which is located two miles north of the first, flowed gas from two zones below the 10,500 foot level at 14 MMcf/d and 14.7 MMcf/d respectively. The third discovery, Shell Limestone Mountain 2A-13, located 8½ miles northwest of the Willson Creek discoveries, flowed gas at 15 MMcf/d from one zone below the 12,000 foot level. Calculated absolute open flow potential of the well was about 53 MMcf/d. Although the initial results are very encouraging, additional test wells will be required before these discoveries can be fully evaluated.

Further north in the foothills, the Rosevear area about 100 miles west of Edmonton is also showing evidence of becoming a major gas-producing region. During the past year, Shell drilled five successful gas discovery wells there. All the discoveries were in the Devonian Beaverhill Lake formation at around 10,500 feet in porosity traps in a limestone platform. The first discovery was made in February 1975 and flowed gas up to 33 MMcf/d. The discoveries added about 300 billion cubic feet to the Rosevear field, now estimated at about 400 billion cubic feet.

Another shallow gas trend is developing in northwestern Alberta, scene of the Keg River oil discoveries of the 1960's. There, several gas discoveries were made in 1974 in the Bluesky formation of Cretaceous age at shallow depths. Currently, several follow-up wells are being drilled in an attempt to expand the known limits of the productive area. Only a short time ago, natural gas from this relatively remote area of Alberta would have been considered economically unattractive by most producing companies. However, with increased prices, production of the gas becomes economic and development of the area is proceeding.

In west-central Alberta, Hudson's Bay Oil and Gas Company Limited recorded three indicated natural gas finds in the Pinto Creek area.

In the southern foothills, PanCanadian Petroleum Limited drilled a successful Mississippian gas well on the Stoney Indian reserve west of Calgary. Both the Mount Head and Turner Valley formations are gas bearing in the new well with about 250 feet of gross pay in these sections. Another exploratory well is scheduled for the area and the company is studying the feasibility of constructing a gas processing plant of approximately 100 MMcf/d to process the new field production.

In east-central Alberta, Houston and Associates drilled two successful exploratory tests about 100 miles east of Edmonton. Although only limited information is available, one of the wells was a dual zone discovery. It is now anticipated that several more wells will be

Table 2. Pressure maintenance projects and storage of natural gas in Canada, 1974-75

	1974 Input	1975p Input
Alberta		
Aerial	210,503	217,632
Ante Creek	1,475,753	1,532,373
Bellshill Lake	94,324	481,689
Bigstone	6,296	171,989
Bonnie Glen	44,497	14,864,096
Carson Creek	5,670,455	6,226,568
Carstairs	295,913	781,668
Crossfield	1,008,602	–
Crossfield East	1,462,395	956,301
Duhamel	246,511	435,344
Golden Spike	22,493,951	9,567,249
Harmattan East	30,851,289	27,864,703
Harmattan Elkton	43,979,713	44,991,151
Joarcam	1,944,894	1,871,423
Judy Creek	2,188,012	29,290
Kaybob South	128,466,652	118,551,433
Leduc-Woodbend	5,701,030	5,578,631
Mitsue	1,696,862	1,449,184
Pembina	2,017,318	1,354,347
Rainbow	16,514,911	11,717,511
Rainbow South	1,834,675	2,613,303
Redwater	1,376,537	145,573
Ricinus	13,062,601	14,363,455
Rowley	78,159	59,585
Swan Hills South	14,826,000	14,652,646
Turner Valley	5,181	–
Waterton	15,955,532	14,797,166
Westerose South	2,549,137	4,128,120
Willesden Green	7,637,977	10,227,161
Windfall	27,155,438	33,982,704
Wizard Lake	27,835,568	15,749,365
Total (14.65 psia)	378,686,686	359,361,660
Total (14.73 psia)	376,641,777	357,421,107
Ontario	98,884,187	124,677,694
Saskatchewan	6,724,297	7,525,983
Total Canada (14.73 psia)	482,250,261	489,624,784

Source: Provincial government reports.
pPreliminary; – Nil.

Table 3. Canada, production of natural gas, 1974-75[1]

	1974		1975[p]	
	(Millions cu.ft.)	($000)	(Millions cu.ft.)	($000)
Gross new production				
New Brunswick	88		91	
Quebec	183		175	
Ontario	7,537		10,885	
Saskatchewan	71,094		69,050	
Alberta	2,970,730		2,983,038	
British Columbia	445,822		433,207	
Northwest Territories and Yukon	1,771		2,017	
Total, Canada	3,497,225		3,498,463	
Waste and flared				
Saskatchewan	9,458		7,748	
Alberta	51,511		37,397	
British Columbia	4,569		3,683	
Northwest Territories and Yukon	792		1,716	
Total, Canada	66,330		50,544	
Reinjected				
Alberta	381,704		358,396	
British Columbia	3,685		2,731	
Northwest Territories and Yukon	—		—	
Total, Canada	385,389		361,127	
Net withdrawals				
New Brunswick	88	44	91	46
Quebec	183	27	175	28
Ontario	7,537	3,248	10,885	5,551
Saskatchewan	61,636	9,001	61,302	9,808
Alberta	2,537,515	645,138	2,587,245	1,655,837
British Columbia[2]	437,568	65,897	426,793	74,861
Northwest Territories and Yukon	979	411	301	36
Total, Canada	3,045,506	723,766	3,086,792	1,746,167
Processing shrinkage				
Saskatchewan	1,710		1,536	
Alberta	408,346		364,103	
British Columbia	43,920		44,592	
Total, Canada	453,976		410,231	
Net new supply, Canada	2,591,530		2,676,561	

Source: Statistics Canada and provincial government reports.
[1]14.73 psia. [2]British Columbia total includes Pointed Mountain gas produced in Northwest Territories and Beaver River gas produced in the Yukon but processed in British Columbia.
[p]Preliminary; — Nil.

Table 4. Canada, production, trade and total sales of natural gas, 1965-75

		Net Withdrawals	Imports	Exports	Sales in Canada
1965	Mcf	1,442,448,070	15,673,069	403,908,528	573,016,495
	$	158,938,464	5,809,335	104,279,744	369,307,232
1966	Mcf	1,341,833,195	43,550,818	426,223,806	635,514,622
	$	179,183,990	17,592,370	108,749,931	416,212,202
1967	Mcf	1,471,724,535	52,871,671	505,164,622	698,223,437
	$	197,983,450	19,914,301	123,663,828	454,722,005
1968	Mcf	1,692,300,787	88,227,825	598,143,763	765,786,814
	$	225,263,658	35,392,758	153,751,558	490,767,434
1969	Mcf	1,977,838,205	37,732,703	669,815,767	843,164,967
	$	262,332,030	16,025,449	176,187,766	537,186,938
1970	Mcf	2,277,108,791	11,877,827	768,112,547	917,440,820
	$	315,099,792	5,123,896	205,988,180	582,316,948
1971	Mcf	2,499,023,600	16,010,217	903,051,071	1,001,328,624
	$	342,548,891	7,021,000	250,719,000	641,898,026
1972	Mcf	2,913,047,178	15,759,538	1,007,053,829	1,145,797,145
	$	388,500,342	7,629,000	306,843,000	740,382,930
1973	Mcf	3,119,460,755	14,699,677	1,030,912,824	1,229,409,641
	$	451,853,205	7,793,000	350,745,000	797,855,930
1974	Mcf	3,045,506,000	9,227,857	960,713,090	1,314,321,000
	$	723,766,000	5,777,000	493,640,000	980,395,000
1975ᵖ	Mcf	3,086,792,000	10,446,971	949,465,252	1,324,705,000
	$	1,746,167,000	7,830,000	1,092,168,000	1,307,287,000

Source: Statistics Canada. Figures in Tables 4 and 12 differ for imports and exports because of different reporting procedures and timing.
^{p} Preliminary.

drilled in the same general area in the immediate future.

As in previous years, much of the development drilling was confined to the shallow gas trends of the southern areas of the province. Chieftain Development Co. Ltd. successfully completed 12 development wells around the periphery of the Tweedie field, substantially increasing its proven reserves. The most ambitious development program in the province was carried out in the Viking-Kinsella field of east-central Alberta. Field boundaries were enlarged and producibility improved by infill and step-out drilling.

British Columbia. Total footage drilled and the number of wells completed was down substantially in 1975. Both exploratory and development work decreased, as aggregate drilling footage declined by over 40 per cent to 421,547 feet. The slowdown in overall drilling activity was mirrored to some extent by the decrease in provincial oil and gas reserves.

Nevertheless, there were some significant gas discoveries made in the province during the year. Probably the most active exploration region was the Helmet area of northeastern British Columbia which had attracted industry interest since the early 1960s. This year the Helmet gas field, discovered several years ago, came on production and was connected to markets via an extension to the Westcoast Transmission Company Limited's main line. Installation of pipeline facilities encouraged industry activity in the area, and efforts were rewarded by several confirmed and potential gas discoveries from several different gas-producing horizons. The primary exploration target is the Devonian Slave Point formation, the producing horizon in the Helmet field. The Helmet field itself has gradually been extended in a northwest-southeast direction and is expected to be further extended to the southeast following results of drilling in 1976.

Farther south in the Sukunka-Grizzly Valley trend, British Petroleum Exploration Canada Ltd. discovered gas in its Bullmoose D77 well. According to official reports the well was successfully completed in the Baldonnel formation, and is located 12 miles southeast of the Triad BP Sukunka A-43-B gas success of September 1965. Elf Oil Exploration and Production Canada Ltd., announced that its well, Elf *et al* Boudreau 4-34 in this region, encountered gas in the Halfway formation. Both are believed to be significant finds.

Most of the development drilling in the province was aimed at the Devonian Slave Point producing trend which includes the Sierra, East Kotcho Lake and Helmet fields.

Yukon Territory, Northwest Territories and Arctic Islands. In the territorial regions exploration fell off considerably and there was a lower success ratio. Forty-four wells were drilled for a total footage of 371,450 feet compared with 60 wells and 503,227 feet in 1974. Thirty-four were classed as exploratory and 6 were classed as potential gas finds.

In the Mackenzie delta, the Shell Niglintagak M-19 well, one mile from a previous discovery, successfully tested nine sandstone zones that totalled about 500 feet, five of these zones were gas bearing and the remainder oil bearing. Preliminary estimates based on both well and seismic data place reserves of this field at about 1 tcf of gas and about 80 million barrels of oil. Elsewhere on the delta, Shell Canada Limited's Kumak J-06 well, drilled in April, encountered both oil and gas below the 4,000-foot level. A 1½-mile successful follow-up well was drilled later in the year and oil and gas flows were encountered in essentially the same horizons as the original discovery. Indications are that the structure is very complex and additional drilling will be required before reserve estimates can be made.

In gas field development, Gulf Oil Canada Limited's Parsons A-44 step-out tested gas at rates up to 15.5 MMcf/d from the Parsons sandstone. The well is located about 1⅓ miles from a previous successful step-out well and seven miles southwest of Parsons Lake F-09 discovery well. Although it is already apparent that the Parsons Lake gas field is of major proportions, the structural setting of the field is complex and several more development wells will be required before its true size is known.

Offshore in the Beaufort Sea, Imperial Oil Limited announced that a successful follow-up well had been drilled from an artificial island about three miles south of its original discovery, Adgo F-28, drilled the previous year. The new well encountered 250 feet of gas-bearing and 140 feet of oil-bearing reservoir between the 2,000 and 5,800 foot level. The reservoir rocks are reported to have excellent porosities, promoting speculation that this discovery may be Canada's first major offshore oil discovery. The geology is considered to be even more favourable for hydrocarbon accumulation offshore than onshore, and industry's confidence in its ability to operate there has contributed to increasing optimism that their efforts will be rewarded by the discovery of major reserves. At year-end, plans were being made to extend the search to deeper waters in the Beaufort Sea. Two drillships, specially strengthened against ice, are now being readied for Dome Petroleum Limited for work there. One of these is currently being constructed in the United States, and the other is the Norwegian self-positioning drillship Havdrill, bought by Dome and now being modified for Arctic operations in Victoria, British Columbia. The drillships are designed to drill offshore during the summer season in from 90 to 2,000 feet of water. They are expected to be operational by the summer of 1976. Dome's permit acreage is approximately 70 miles north of the Adgo artificial island.

In the Arctic Islands, Panarctic Oils Ltd. announced that its Panarctic East Drake I-55 well had established a major extension to the already sizeable Drake Point

Table 5. Canada, liquids and sulphur recovered from natural gas, 1965-75

	Propane	Butane	Condensate Pentanes Plus	Sulphur
	(barrels)	(barrels)	(barrels)	(long tons)
1965	10,168,610	6,927,505	27,867,535	1,589,586
1966	12,473,645	8,177,144	29,365,322	1,729,455
1967	14,146,829	9,327,710	30,741,400	2,168,646
1968	15,855,467	10,421,958	33,202,168	3,042,105
1969	17,807,022	11,184,685	38,534,025	3,714,312
1970	21,274,353	13,203,744	44,151,409	4,240,982
1971	24,225,504	15,447,329	46,898,136	4,555,290
1972	29,540,846	19,458,808	60,829,459	6,617,216
1973	33,433,765	22,436,765	62,061,744	7,003,489
1974	33,135,301	22,137,859	59,206,276	6,840,550
1975p	34,809,037	22,915,802	55,451,536	6,468,501

Sources: Statistics Canada and provincial government reports.
pPreliminary.

gas field on the east coast of the Sabine Peninsula on Melville Island. The step-out well was drilled from an ice-pad eight miles offshore. The well encountered a similar gas-bearing sandstone as onshore tests in the same field. The length of the Drake Point field has now been established at over 25 miles and it can now be classified in the major gas field category. On the west coast of the peninsula, Panarctic completed a successful step-out well that substantially extended the east boundary of the Hecla field. The western limits of the field were enlarged in 1974 by the drilling of a well eight miles offshore. In an attempt to further extend the western boundaries of the field, Panarctic commenced drilling two more offshore follow-up wells from ice-pads early in 1976. The location of the first well is nine miles offshore, 1½ miles west of the previous extension, and when this is completed, the drilling rig will be moved seven miles further west where another offshore test will be drilled. In the event that these two ventures prove to be successful, there is little doubt that the Hecla field will be the largest gas discovery in Canada, larger than the Drake Point field which is believed to contain over 6 tcf of gas. If favourable results are obtained elsewhere in the arctic Islands during the 1976 drilling season, then the minimum reserve base for economic development should be close at hand. Current estimates place this limit in the 20-25 tcf range.

Saskatchewan. The number of wells and footage drilled declined again in Saskatchewan in 1975. The number of wells drilled was down from 288 to 267 and footage declined from 706,133 feet to 649,205 feet. Both exploratory and development drilling decreased. Successful gas well completions fell from 126 in 1974 to 85 in 1975. Six of these were new discoveries and the bulk of the remainder consisted of development wells in the expanding shallow gas fields in the southwestern corner of the province.

As in the previous year, the most significant gas discovery in the province during 1974 was made by the Saskatchewan Oil and Gas Corporation (Saskoil) in southwestern Saskatchewan. The producing zone is the Viking sandstone which yielded up to 2.9 MMcf/d on a drillstem test. The discovery well is situated two and one-half miles north of the Totnes gas-producing area and three and one-half miles east of the Brock East gasfield limits.

Eastern Canada. Offshore from the east coast, nine exploratory wells were drilled for a total of 86,330 feet in 1975 compared with 19 wells and 185,352 feet in 1974. Drilling commenced in this region in 1966 and

Table 6. Wells drilled, by province, 1974-75

	Oil		Gas		Dry[1]		Total	
	1974	1975[p]	1974	1975[p]	1974	1975[p]	1974	1975
Western Canada								
Alberta	651	670	1,719	1,958	1,270	1,204	3,640	3,832
Saskatchewan	71	105	126	85	91	77	288	267
British Columbia	6	2	47	31	93	48	146	81
Manitoba	5	2	—	—	15	5	20	7
Yukon and Northwest Territories and Arctic Islands	2	3	10	6	48	35	60	44
Westcoast offshore	—	—	—	—	—	—	—	—
Subtotal	735	782	1,902	2,080	1,517	1,369	4,154	4,231
Eastern Canada								
Ontario	4	4	60	68	90	66	154	138
Quebec	—	—	—	—	6	3	6	3
Atlantic provinces	—	—	—	—	—	7	—	7
Eastcoast offshore	—	—	—	—	19	9	19	9
Hudson Bay offshore	—	—	—	—	2	—	2	—
Subtotal	4	4	60	68	117	85	181	157
Total Canada	739	786	1,962	2,148	1,634	1,454	4,335	4,388

Source: Canadian Petroleum Association.
[1] Includes suspended and abandoned wells.
[p] Preliminary; — Nil.

Table 7. Footage drilled in Canada for oil and gas by province, 1974-75

	Exploratory[1]		Development[2]		All Wells[3]	
	1974	1975*p*	1974	1975*p*	1974	1975*p*
Alberta	5,186,825	4,781,048	6,808,017	7,191,296	11,994,842	11,972,344
Saskatchewan	356,218	292,748	349,915	356,457	706,133	649,205
British Columbia	449,567	277,618	310,797	143,929	760,364	421,547
Manitoba	55,253	11,901	16,807	10,037	72,060	21,938
Territories and Arctic Islands	472,900	283,379	30,327	88,071	503,227	371,450
Westcoast offshore	—	—	—	—	—	—
Total Western Canada	6,520,763	5,646,694	7,515,863	7,789,790	14,036,626	13,436,484
Ontario	153,658	121,684	88,187	93,069	241,845	215,553
Quebec	27,705	9,963	—	—	27,705	9,963
Atlantic Provinces	—	56,215	—	—	—	56,215
Eastcoast offshore	185,352	86,330	—	—	185,352	86,330
Hudson Bay offshore	9,511	—	—	—	9,511	—
Total Eastern Canada	376,226	274,192	88,187	93,069	464,413	368,061
Total Canada	6,896,989	5,920,886	7,604,050	7,883,659	14,501,039	13,804,545

Source: Canadian Petroleum Association.
[1]Exploratory total includes new field wildcats, new pool wildcats, exploratory footage of deeper pool tests, shallower pool tests, outposts, and stratigraphic tests. [2]Development total includes remainder of footage for deeper pool tests not included in exploratory total. [3]All wells total excludes potash wells and miscellaneous wells.
*p*Preliminary; — Nil.

since then a total of 130 wells have been drilled, of which seven and possibly nine have been significant oil and gas discoveries. The three most important of these were made in 1974, one off the east tip of Prince Edward Island and two on the Labrador Shelf. Two more potential gas discoveries were made offshore on the Labrador Shield in 1975. Both were drilled by Eastcan Exploration Ltd. and both had to be suspended before completion because of inclement weather. The first, Eastcan Snorri J-90, was drilled to a total depth of 10,531 feet and mechanical log evaluation indicated the possibility of hydrocarbons in a porous zone below 8,174 feet. Present plans call for re-entering the well in 1976, drilling to total depth and fully evaluating all producing zones. The well is located 140 miles north of the Eastcan *et al* Bjarni H-81, and 220 miles north of the Eastcan *et al* Gudrid H-55 discovery wells. The northernmost well, Karlsefni H-13, located about 880 miles north of St. John's, Newfoundland, was drilled to a depth of 10,774 feet and suspended. Eastcan is expected to re-enter the well in 1976 and drill to the planned depth of 16,500 feet before evaluating potential hydrocarbon producing zones.

On the Grand Banks and Scotian Shelf, exploratory drilling has virtually ceased, as results to date have been costly and disappointing. The only discoveries in this region have been made in the vicinity of Sable Island. Mobil Oil Canada, Ltd. intends to suspend, for an indefinite period, all east coast exploration. Mobil, as one of the pioneers in offshore east coast exploration, during its 10 years of operations there has drilled 26 wells, resulting in four separate discoveries: Sable Island, Thebaud, Cohasset and Citnalta, none of which are considered to be commercial. In making the announcement, Mobil stressed that it was not abandoning the east coast as an exploration prospect but rather, has decided that a careful study of the results of its exploration program in that area over the past 10 years is required to formulate ongoing long-range plans.

Elsewhere in the Maritimes and Quebec, the team of Gulf and Mobil abandoned their exploratory test in the Bay of Fundy at a depth of 8,000 feet without encountering any significant indications of either oil or gas. On Prince Edward Island, the Quebec crown corporation Quebec Petroleum Operations Company (SOQUIP) abandoned two exploratory wells after encountering non-commercial indications of gas. In Quebec, three exploratory tests were drilled in 1975 in the St. Flavien and Veilleray districts near Quebec City. Some of the wells were reported to have yielded fairly substantial flows of gas on being subjected to stimulation techniques, but their potential is still to be determined.

In Ontario, during the past year, 138 exploratory and development wells were drilled compared with 154 exploratory and development wells drilled in 1974. Of these, 68 were classified as gas discoveries. Most of the gas discoveries were confined to Silurian pinnacle reefs located along the eastern flank of the Michigan Basin in Lambton County. One Devonian gas discovery was made by The Consumers Gas Company on the north shore of Lake Erie, flanking the Appalachian Basin. The bulk of the gas development drilling was concentrated in Lake Erie where Consumers Gas and other operators have discovered several Devonian fields in recent years.

Reserves

Annual estimates made by the Canadian Petroleum Association (CPA) show that proved remaining marketable reserves of natural gas in Canada amounted to 56,974,716 MMcf at the end of 1975. This is an increase of 226,630 MMcf or less than 1 per cent during the past year, and considerably less than the 8 per cent increase obtained in 1974. Using the 1975 level of production, i.e. net new supply from Table 12, the life index (reserves to production ratio) for natural gas declined to 21.3 years. Gross addition to reserves amounted to 2.6 tcf, including .36 tcf attributed to new discoveries, 2.4 tcf to extensions of existing fields and a downward revision of .18 tcf to previously-estimated field reserves. Almost all of the increase was accounted for by increases in reserves in Alberta. Gross additions of marketable gas in Alberta amounted to 3.9 tcf and most of this was due to revisions and extensions of existing fields; .36 tcf was accounted for by new discoveries. Gas reserves in the territories, which includes the Mackenzie delta, declined by 1.14 tcf, primarily by revisions of previous estimates. Confidential information released by the operating companies in the delta at recent hearings held by the National Energy Board into future availability of gas in Canada was responsible for this negative revision. In placing these reserves in the proven category, the CPA assumed that delta gas would eventually be brought to market via the same pipeline system as Prudhoe Bay gas from Alaska; therefore, no thereshold volumes were required before categorizing them as proven. This is not the case for Arctic Island gas where a minimum reserve base is required before this gas can be considered to be within economic reach. Therefore, gas reserves that have been found in the Arctic islands are classified as probable rather than proven. Alberta, with 45.32 tcf of marketable gas reserves, accounted for 80 per cent of Canadian reserves at the end of 1975, British Columbia 12 per cent and the territories 6 per cent.

Natural gas processing

No new large gas processing plants came on stream in 1975 although some smaller units and additions to existing facilities occurred. As a result, total gas processing capacity declined for the second consecutive year. At the end of 1975 gas processing capacity amounted to 16,456 MMcf/d.

Table 8. Canada, estimated year-end marketable reserves of natural gas, 1974-75

	1974	1975
	(millions of cubic feet)	
Alberta	43,376,959	45,324,508
British Columbia	7,304,848	6,839,724
Saskatchewan	972,530	897,353
Eastern Canada	238,214	266,451
Northwest Territories	4,815,535	3,646,680
Total	56,708,086	56,974,716

Source: Canadian Petroleum Association.

The largest project completed in 1975 was the Texaco Exploration Canada Ltd. gas cycling plant at the Bonnie Glen oil and gas field. The cycling plant will process sour wet gas from the gas cap and reinject the residue gas for pressure maintenance of the oil zone, after removing nearly all of the natural gas liquids. The plant has two novel features, including a turbo expander process with the potential for conversion to future ethane recovery if required. Another unique feature of the process design is the absence of H_2S removal. This is one of the few plants in North America that is designed to process sour gas without intermediate sweetening prior to entry into the cryogenic system. When fully operational it will process 140 MMcf/d of raw gas and recover over 10,000 b/d* of propane, butane and pentanes plus.

The largest expansion to existing plants was carried out by Westcoast Transmission Company Limited at its Fort Nelson plant where the firm installed a 150 lt/d** sulphur recovery plant at a cost of $13 million. Other expansion programs included Pacific Petroleums Ltd's addition of a new unit to its Kaybob plant. The unit will increase raw gas capacity by 25 MMcf/d of residue gas, and 3,000 b/d of natural gas liquids. At Ram River, Aquitaine Company of Canada Ltd. increased the raw gas capacity of its plant to 422 MMcf/d. At this plant, hydrogen sulphide is removed by 4 Claus recovery units. The tail gas is cleaned up by the Sulfreen process, bringing total sulphur extraction to 98 per cent.

Maynard Exploration Company placed its East Drumheller gas processing plant and field gathering pipeline system on stream in 1975. Design capacity of this refrigeration-compression plant is 20 MMcf/d raw gas intake, 19 MMcf/d of residue gas and 90 b/d of

*b/d — Barrels a day.
**lt/d — Long tons a day.

Table 9. Canada, natural gas processing plant capacities by fields, 1975

Main Gas Field Served	Raw Gas Capacity	Residue Gas Produced
	(million cf/day)	
Alberta		
Acheson	6	5
Alderson	12	12
Alexander, Calahoo	36	35
Bantry	14	12
Bassano	8	8
Big Bend	20	20
Bigoray	13	12
Bigstone	48	36
Black Butte	10	10
Black Diamond	12	11
Bonnie Glen (2 plants)	188	166
Boundary Lake South	17	13
Braeburn	6	5
Brazeau River	196	171
Brazeau South	66	60
Bruce	30	
Burnt Timber	68	57
Cadomin	25	24
Calling Lake	18	18
Carbon	155	150
Caroline (2 plants)	58	49
Carson Creek	100	62
Carstairs	334	280
Cessford (5 plants)	209	203
Cessford North	7	6
Chigwell (2 plants)	7	5
Connorsville, Cessford	5	5
Corbett Creek	9	9
Countess (2 plants)	57	55
Crossfield (2 plants)	315	215
Dunvegan	240	235
East Crossfield	146	87
East Rainbow Lake	18	11
Edson	377	339
Enchant	5	5
Equity, Ghost Pine	16	15
Ferrier (2 plants)	110	90
Ferrier South	20	19
Ferrybank	21	20
Garrington	15	14
Ghost Pine	110	108
Gilby (6 plants)	161	135
Gilby North	19	18
Gold Creek	56	15
Golden Spike	90	reinj
Greencourt	30	28
Hanna	12	8
Harmattan-Elkton (2 plants)	535	315
Harmattan-Elkton South	5	4
Alberta (cont'd)		
Hatton	8	7
Holmberg	12	12
Homeglen-Rimbey	423	357
Hussar	100	90
Huxley	13	10
Innisfail	20	13
Joffre	8	5
Judy Creek, Swan Hills (3 plants)	296	220
Jumping Pound	250	200
Kaybob	99	96
Kaybob South (3 plants)	827	284
Kessler	6	5
Keystone	8	7
Killam	10	10
Lac La Biche	18	18
Leduc Woodbend	35	30
Leedale	4	4
Lone Pine Creek	67	54
Marten Hills	133	130
Marten Hills South	24	24
McLeod River	7.5	6
Mikwan North	15	13
Minnehik-Buck Lake	108	100
Mitsue	21	15
Morinville St. Albert-Big Lake	22	20
Nevis, Stettler (2 plants)	225	182
Nipisi	25	15
Okotoks	30	13
Olds	100	76
Oyen (2 plants)	5	5
Paddle River	30	28
Parflesh	2	2
Peco	12	11
Penhold	6	6
Phoenix	3	3
Pembina (12 plants)	142	101
Pincher Creek	90	69
Plain	40	40
Prevo	5	4
Princess (2 plants)	15	15
Provost (5 plants)	153	145
Quirk Creek	90	68
Rainbow Lake	85	reinj
Redwater	22	8
Retlaw	22	14
Ricinus	75	60
Rockyford	5	5
Rosevear	31	26

Table 9. (cont'd)

Main Gas Field Served	Raw Gas Capacity	Residue Gas Produced
	(million cf/day)	
Alberta (cont'd)		
Savanna Creek	75	63
Sedalia	5	5
Sibbald	6	5
Simonette (2 plants)	39	29
South Lone Pine Creek	35	26
Stanmore	27	21
Strachan D-3	275	214
Strachan, Ricinus West	422	257
Sturgeon Lake South	23	17
Swalwell	4	4
Swan Hills	9	4
Sylvan Lake (3 plants)	96	87
Three Hills Creek	10	9
Turner Valley	40	25
Twining Swalwell	10	9
Virginia Hills	12	10
Vulcan	25	22
Waite Court	65	61
Waskahigan	16	14
Waterton	468	311
Wayne-Rosedale	68	62
Wildcat Hills	112	95
Willesden Green	17	15
Wilson Creek (2 plants)	22	19
Wimborne	64	50
Windfall, Pine Creek	215	132
Wintering Hills	14	13
Wood River	5	5
Worsley	23	21
Pipeline at Ellerslie[1]	70	66

Main Gas Field Served	Raw Gas Capacity	Residue Gas Production
	(million cf/day)	
Alberta (cont'd)		
Pipeline at Empress[2] (2 plants)	3,000	2,892
Pipeline at Cochrane[3]	1,000	970
Saskatchewan		
Cantuar	25	24
Coleville, Smiley	38	37
Hatton	8	7
Dollard	2	2
Milton	4	4
Smiley	2	1
Steelman	38	30
Totnes	7	7
West Gulf Lake	15	14
British Columbia		
Beaver River	240	240
Boundary Lake (2 plants)	29	27
Clarke Lake	1,100	910
Fort St. John	500	440
Ontario		
Becher	1	1
Corunna (2 plants)	5	5
Port Alma	16	16
Northwest Territories		
Pointed Mountain	189	189

Source: *Natural Gas Processing Plants in Canada* (Operators List 7) January 1973, Department of Energy, Mines and Resources, Ottawa.

[1]Plant reprocesses gas owned by Northwestern Utilities Limited. [2]Plant reprocesses gas owned by TransCanada PipeLines Limited. [3]Plant reprocesses gas owned by exporting companies.

stabilized condensate. Residue gas is under contract to TransCanada PipeLines Limited. In the Carrigton field, Mesa Petroleum Co.'s compression-absorption plant came on stream late in the year. This plant produces 712 b/d of propane and mixed liquid petroleum gases (LPG's) from a raw gas intake of 15 MMcf/d. Norcen Energy Resources Limited, formerly Canadian Industrial Gas & Oil Ltd., constructed two small gas processing plants in 1975. One of these is in the McLeod River field, producing 125 b/d of pentanes plus from 7.5 MMcf/d of raw gas intake. The other is located at the Bruce field and produces 10 b/d of pentanes plus from a raw gas intake of 30 MMcf/d. Ocelot Industries Ltd. has completed its second plant in the Foothills Belt of Alberta, south of the Edson field. This plant was constructed at the north end of the Peco field and is a dehydration-refrigeration type with a maximum design capacity of 7.4 MMcf/d raw gas intake, 6.1 MMcf/d of residue gas and 579 b/d of stabilized condensate. Ocelot has recently received permission from the Alberta Energy Resources Conservation Board to construct another small plant four miles northwest of the Dismal Creek gas plant in the same general area. The second plant is expected to go on stream early in 1976.

The lack of major gas field discoveries in recent years, coupled with the long lead time required to construct a major gas processing plant, make it unlikely that any large new plants will come on stream before 1978. In 1976 three medium-sized projects are likely to be completed, the first of which in Sun Oil Company Limited's Rosevear plant. When in full operation it will process 31 MMcf/d of intake gas to produce 26 MMcf/d of dry residue gas, 260 b/d of pentanes plus and 81 lt/d of sulphur. Hudson's Bay Oil and Gas Company Limited's Zama plant is expected to come on stream in mid-1976. It is a modular plant for on-site assembly. The method of construction is becoming the recognized format for remote wilderness locations to reduce on-site construction. The third project in the medium-size category expected to be completed in 1976, is Canada-Cities Service, Ltd.'s expansion of its Mayerthorpe plant in the Paddle River area. Expansion commenced in 1975 and will be completed about mid-1976. Raw gas capacity will be increased to 78.8 MMcf/d with production of 1,235 b/d of propane and mixed LPG's. A sulphur recovery unit has also been installed and it will produce 17.4 lt/d of sulphur.

In the Mackenzie delta where several major gas discoveries have been made, a proposal to build two gas processing plants of 1.5 bcf/d* capacity has been submitted to the federal government by a joint development group comprising Gulf Oil Canada Limited, Imperial Oil Limited, and Shell Canada Limited. The $1 billion project would involve the construction of a 1 bcf/d gas plant to be located at the Taglu field to process gas from this field and the Niglintgak field, 10 miles further west. The second plant, with a proposed capacity of 500 MMcf/d, is for the Parsons Lake field, about four miles southwest of the Taglu field.

Transportation

A total of 2,091 miles of pipeline was added to gas transmission, distribution and gathering systems in Canada during 1975 compared with 2,355 in 1974. Total cumulative gas pipeline mileage now stands at 75,103 miles. Transmission pipeline construction in 1975 was restricted to 307 miles, much of which consisted of looping (parallel line construction) to main trunklines. Among the most important of these projects was that of TransCanada PipeLines Limited. This company completed the looping of its 36-inch natural gas pipeline from Winnipeg to Toronto which it started in 1967. TransCanada also began looping its line between Toronto and Montreal, adding 47.9 miles of 24-inch pipe. It also increased the capacity of the Ottawa lateral by adding 17 miles of 16-inch loop. The remaining 23 miles of new large-diameter line installed consisted of 11 miles of replacement 42-inch line in southwestern Ontario by Union Gas Limited, and 8.3 miles of 42-inch and 3.7 miles of 30-inch line laid by The Alberta Gas Trunk Line Company Limited in Alberta. The largest single pipeline construction program of the year was carried out by Inland Natural Gas Co. Ltd. in British Columbia. Construction consisted of 70 miles of 12-inch line between Yahk and Salmo and links with the first 33 miles laid last year between Trail and Salmo to provide service through to Trail as an alternative to its main supply source from Westcoast Transmission Company Limited. The gas supply for the new line will be provided by Alberta Natural Gas Company Ltd.'s 36-inch main line at Yahk in the southern Columbia River Valley.

About 1,400 miles of small-inch distribution construction was carried out in 1975. As in previous years most of this construction was in Alberta, primarily by The Alberta Gas Trunk Line Company Limited in the eastern portion of its system.

Construction of gas gathering systems, at 390 miles, was down 70 per cent from 1974 mileage. The largest projects were completed in the southeastern corner of Alberta where looping and extension of several large-diameter gathering laterals was carried out to bring new fields in this region into production for TransCanada PipeLines Limited. The main elements of this program consisted of 145 miles of 2 to 10-inch line from the Princess field to the Halkirk field via Sunnynook and 125 miles of 2 to 8-inch in the Alderson field. A smaller project included Northwestern Utilities Limited's 25-mile extension to its 24-inch line between the Bonnie Glen field and the Homeglen Rimbey gas processing plant of Gulf Oil Canada. The extension runs between Texaco Exploration Canada Ltd.'s gas processing plant to Calmar, just south of Edmonton.

In March of 1974, Canadian Arctic Gas Study Limited (CAGSL) filed an application with the NEB to build a natural gas pipeline from Alaska's North slope and the Mackenzie delta to southern markets. CAGSL, a consortium of 18 Canadian and United States companies, proposes to build a 48-inch pipeline that would carry natural gas from Alaska and the Mackenzie delta to markets in Canada and the United States. The 2,400-mile pipeline would cost an estimated $7 billion. In April, 1975, Foothills Pipe Lines Ltd., formed by The Alberta Gas Trunk Line Company Limited and Westcoast Transmission Company Limited, both former members of CAGSL, also submitted an application to the NEB to construct a pipeline from the Mackenzie delta to the south. Their proposed 820-mile, 42-inch line would join up with existing distribution systems in Alberta and British Columbia and bring only Canadian gas to Canadian markets. Cost of this line is estimated to be $2.3 billion, with an additional $1.7 billion required to expand existing southern systems.

The NEB commenced a series of public hearings on October 27, 1975, to determine if it was feasible to build a natural gas pipeline from the Arctic region and at the same time assess the competing applications of the CAGSL and Foothills consortiums. The pipeline hearings were divided into six parts with different

*bcf/d = Billion cubic feet a day.

Table 10. Gas pipeline mileage in Canada 1971-75ᵉ

	1971	1972	1973	1974	1975ᵉ
Gathering					
New Brunswick	6	6	6	6	6
Quebec	1	1	1	1	1
Ontario	1,102	1,136	1,259	1,134	1,128
Saskatchewan	875	922	963	751	755
Alberta	4,243	4,202	4,810	5,608	5,985
British Columbia	948	989	1,025	1,079	1,093
Northwest Territories and Yukon	—	—	—	34	35
Total	7,175	7,256	8,064	8,613	9,003
Transmission					
New Brunswick	13	13	13	13	13
Quebec	148	148	148	148	148
Ontario	3,711	4,350	5,226	5,741	5,816
Manitoba	1,444	1,590	1,641	1,644	1,647
Saskatchewan	5,361	5,996	6,364	6,533	6,563
Alberta	7,206	7,816	8,081	7,987	8,066
British Columbia	2,718	2,967	3,032	3,041	3,161
Total	20,601	22,880	24,505	25,107	25,414
Distribution					
New Brunswick	32	32	32	32	32
Quebec	1,638	1,693	1,723	1,718	1,788
Ontario	16,100	16,602	16,395	17,023	17,403
Manitoba	1,630	1,708	1,771	1,825	1,851
Saskatchewan	2,356	2,547	2,711	2,868	2,976
Alberta	7,843	8,657	9,269	10,267	10,847
British Columbia	5,517	5,864	6,187	5,559	5,789
Total	35,116	37,103	38,088	39,292	40,686
Total Canada	62,892	67,239	70,657	73,012	75,103

Source: Statistics Canada.
— Nil; ᵉEstimated.

filing deadlines for prepared testimony from participants. The first three will deal with gas supply and demand; the fourth will examine facilities design, operation and maintenance and construction timing along with alternative systems; the fifth, financial details; and the sixth, public interest considerations, including many of the areas already under examination by the judicial enquiry under Justice T.R. Berger into potential impact of a pipeline on northern life styles that has been under way since the spring of 1975.

The status of the Polar Gas Project, which proposes constructing a 48-inch, island-hopping pipeline to deliver natural gas to southern markets from the Arctic Islands is little changed from the previous year. The problem is not so much as one of constructing the line, although it would be difficult, but rather, in establishing sufficient gas reserves to justify the huge capital expenditures required for its construction.

Markets and trade

Total natural gas sales decreased by 2,012 MMcf to an estimated 2,271,496 MMcf in 1975. The overall decline was attributable to the fall in export sales to 2,593 MMcf/d from the previous year's total of 2,628 MMcf/d. Domestic sales increased to 3,629 MMcf/d — 29 MMcf/d more than in 1974.

Domestic commercial users again led the way in consumption growth rate with a gain of 3.8 per cent to 783 MMcf/d, while sales in the residential market rose by about 2 per cent to 819 MMcf/d. Consumption by industrial users marginally decreased to 2,026 MMcf/d. Total revenue from all sales of gas in Canada

Table 11. Canada sales of natural gas by province, 1975ᵖ

	MMcf	($000)	Average $/Mcf	Number of Customers Dec. 31/75
New Brunswick	82	204	2.49	737
Quebec	82,379	118,969	1.44	190,929
Ontario	637,543	753,594	1.18	1,018,572
Manitoba	60,261	67,206	1.12	154,599
Saskatchewan	92,111	67,951	0.74	184,264
Alberta	307,556	155,828	0.51	413,136
British Columbia	144,773	143,535	0.99	337,802
Total Canada	1,324,705	1,307,287	0.99	2,300,039
Previous totals				
1971	1,001,329	641,898	0.64	1,958,083
1972	1,145,797	740,383	0.65	2,039,095
1973	1,229,440	797,856	0.65	2,131,090
1974	1,314,321	980,395	0.75	2,219,549

Source: Statistics Canada.
ᵖPreliminary.

and from exports amounted to $2,399 million in 1974; of this amount, domestic sales accounted for $1,307 million — 33 per cent more than 1974 sales of $980 million. The value of export sales rose to $1,092 million, more than doubling the $494 million 1974 sales. Alberta accounted for the bulk of the increase in Canadian consumption in 1975, commercial sales being the major factor in increasing provincial consumption by 27 MMcf/d to 842 MMcf/d. Although Ontario remained the largest user, consuming 48 per cent of all gas used in Canada, sales declined by 2.2 per cent to 1,746 MMcf/d. Alberta is the second-largest consuming province and accounted for 23 per cent of all gas marketed in Canada in 1975. Markets in British Columbia averaged 397 MMcf, increasing by 12 per cent over 1974 consumption. However, this is still less than consumption was in 1973 when the decline in production set in at the Beaver River and Pointed Mountain fields — two of the province's principal gas suppliers.

Sales in Quebec remained about the same as in the previous year at 225 MMcf/d, as the delivery of additional Alberta gas production into that province did not materialize in 1975. The new gas sales agreement between Pan-Alberta Gas Ltd. of Calgary and Gas Métropolitain, inc. of Montréal received approval late in 1974 and called for Pan-Alberta to supply the Quebec market initially with 40MMcf/d beginning on November 1, 1975. However, Pan-Alberta was unable to obtain permission from TransCanada PipeLines to use TransCanada's line to transport its gas to Quebec. TransCanada is a competing buyer as well as a wholesaler in four provinces east of Alberta and is reluctant to move gas for other parties from Alberta as long as it remains short of gas supplies for its own purposes. Pan-Alberta is a wholly-owned subsidiary of the Alberta Gas Trunk Line Company Limited and was originated in 1972 to contract for excess gas production capability in Alberta and resell the gas on a short-term basis. The customers are committed to resell equivalent quantities of gas to Pan-Alberta from Alaska or northern Canada sources in the future.

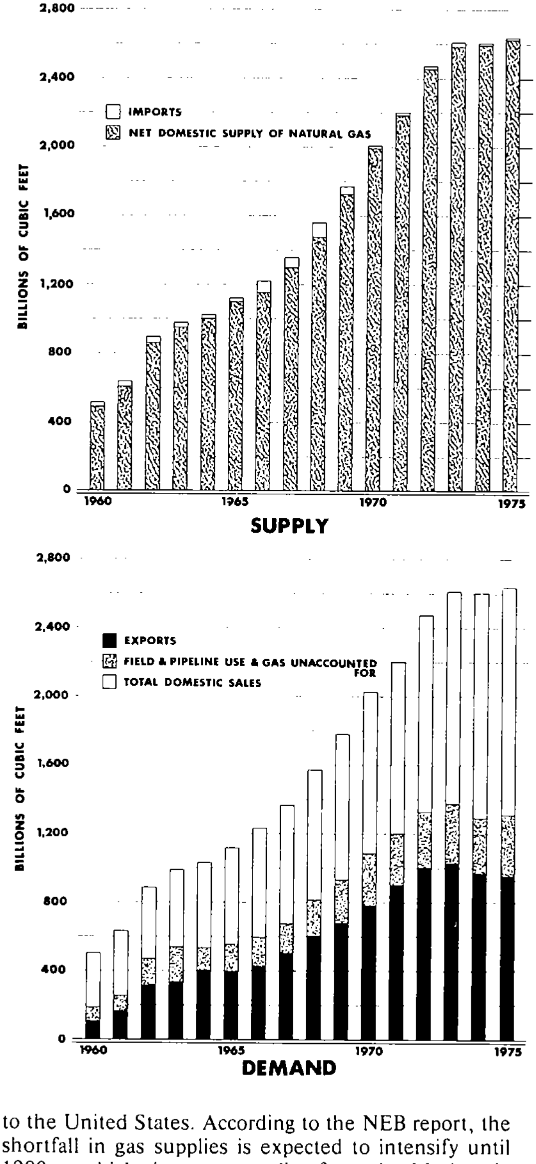
Sales in New Brunswick, Manitoba and Saskatchewan remained at about the same level as in the previous year. The remaining three provinces; Nova Scotia, Prince Edward Island and Newfoundland, do not have natural gas service.

Exports to the United States decreased by 1 per cent to 2,593 MMcf/d, largely because Westcoast Transmission Company Limited has been unable to meet its contractural requirements with United States customers. Maximum approved export volumes average about 2,849 MMcf/d including 1,934 MMcf/d moving into west coast markets and about 915 MMcf/d for midwestern and eastern markets.

In regard to future exports and within the framework of the recommendations of the report "Canadian Natural Gas — Supply and Requirements" recently prepared by the NEB, the federal government announced its intention to cut back natural gas exports and reduce natural gas use by domestic industry and utilities because of the shortage of gas predicted to begin in 1976. The timing and amounts of the cutbacks will be determined only after discussions between the federal and provincial governments, and the government of the United States. Currently, Canada is producing about 2.6 trillion cubic feet of marketable gas annually, of which about 1 trillion cubic feet is exported

SUPPLY-DEMAND of NATURAL GAS in CANADA

MINERAL DEVELOPMENT SECTOR
DEPARTMENT OF ENERGY, MINES AND RESOURCES



to the United States. According to the NEB report, the shortfall in gas supplies is expected to intensify until 1980 at which time gas supplies from the Mackenzie delta may be available supplemented by gas from the Arctic islands in 1983.

As with oil, the federal government was involved in natural gas pricing, in both the export and domestic markets, in 1975. In respect to exports, the federal government announced that the price of natural gas exported would increase to $1.40/Mcf effective August 1, 1975 and be further increased to $1.60/Mcf as of November 1, 1975. This follows an earlier increase to $1.00 an Mcf, effective on January 1, 1975 which came as a result of a report submitted by the NEB. The principal thrust of the NEB report was that the export price of natural gas must be based on its true commodity value in the related export market areas and the replacement of the gas currently being exported will involve higher costs than previously anticipated. The new price came after a further review of export prices by the NEB in March.

In the domestic market the federal government, after consultation with the provinces, raised the price of gas from a level of approximately 82 cents to $1.25 an Mcf at the Toronto city gate. At the same time, and in line with its program to encourage oil and gas exploration, the federal government decided that gas producers should benefit from the increased export prices. Accordingly, it decided that the increased export revenues would be returned to Alberta for apportionment amongst all gas producers in the province. It is estimated that the average net-back for Alberta gas after both the domestic and export price increases, amounted to about 24 cents per Mcf. This would raise the average wellhead price to a level approaching $1.00 per Mcf.

The agreement between the federal government and producing provinces on domestic price levels for oil and natural gas expires June 1976. It will be renewed again in the spring of 1976 but the federal government is committed to have Canadian oil prices increased towards international prices and it is also committed to eliminate the current underevaluation of natural gas with respect to crude oil within a three- to five-year period.

In British Columbia, gas marketing is controlled by the British Columbia Petroleum Corporation, a crown corporation which is empowered by the British Columbia government to engage in production, processing, transmission and marketing of natural gas. The crown corporation buys all the province's gas directly from the producer and sells it to distributing companies in both domestic and export markets. The wellhead price is set by the British Columbia Energy Commission and is based on current competitive energy value. In order to stimulate lagging exploration in the province, the British Columbia Petroleum Corporation increased the price paid to natural gas producers to 55 cents per Mcf for "new" gas and up to 35 cents per "old" gas, depending on the amount of exploration conducted by the producing company. New gas is that produced from pools which began production after November 1, 1974. The new price increase became effective November 1, 1975.

Composition and uses of natural gas

Marketed natural gas consists chiefly of methane (CH_4) but small amounts of other combustible hydrocarbons such as ethane (C_2H_6) and propane (C_3H_8) may also be present. Methane is nonpoisonous and odourless, but a characteristic odour is usually introduced into marketed natural gas as a safety measure. The heat value of natural gas averages about 1,000 British thermal units per cubic foot of gas.

Raw natural gas, as it exists in nature, may vary widely in composition. Besides the usually-predominant methane, varying proportions of ethane, propane, butane and pentanes plus may be present. Water vapour is a normal constituent. Hydrogen sulphide, although not present in some Canadian natural gas, is

Table 12. Canada, supply and demand of natural gas

	1974		1975[p]	
	MMcf	MMcf	MMcf	MMcf
Supply				
Gross new production		3,497,225		3,498,463
Field waste and flared		-66,330		-50,544
Reinjected		-385,389		-361,127
Net withdrawals		3,045,506		3,086,792
Processing shrinkage		-453,976		-410,231
Net new supply		2,591,530		2,676,561
Removed from storage	101,076		112,073	
Placed in storage	-135,674		-166,828	
Net storage		-34,598		-54,755
Total net domestic supply		2,556,932		2,621,806
Imports		13,408		10,220
Total supply		2,570,340		2,632,026
Demand				
Exports		959,187		946,791
Domestic sales				
Residential	292,961		299,219	
Industrial	745,929		739,597	
Commercial	275,431		285,889	
Total		1,314,321		1,324,705
Field and pipeline use				
In production	197,324		230,971	
Pipeline	114,690		122,751	
Other	27,738		21,357	
Adjustment metering differences	-25,932		-26,784	
Line pack changes	2,299		2,224	
Total field and pipeline use		316,119		350,519
Gas unaccounted for		-19,287		10,011
Total demand		2,570,340		2,632,026
Total domestic demand		1,611,153		1,685,235
Average daily domestic demand		4,414		4,617

Sources: Statistics Canada and provincial government reports.
[p]Preliminary.

commonly so abundant as to be an important source of sulphur. Other nonhydrocarbon gases which may be present, usually in small amounts, are carbon dioxide, nitrogen and helium.

The largest use of natural gas is as a fuel. Residentially, gas is extensively used in space and water heating and cooking, but is becoming common as a fuel for air conditioners, incinerators, dishwashers and laundry equipment. In industrial areas, natural gas has been a boon to such industries as automobile plants, iron and steel complexes, metal-working firms, glass factories and food processors. For example, in steelworking, the clean, easily-controlled flame of natural gas enables the desired temperatures to be attained in rolling, shaping, drawing and tempering steel. Natural gas is also a major source of feedstock for the chemical industry. Ethane, seldom removed from natural gas at the field processing plant in the past, has become a valuable petrochemical feedstock and ethane recovery on a large scale is now taking place. Natural gas supplies basic raw material for ammonia, plastics, synthetic rubber, insecticides, detergents, dyes and synthetic fibres such as nylon, orlon and terylene. Important future uses may include fuel-cells and power-generator systems driven by gas turbines.

Canada continues to be one of the world's largest producers of elemental sulphur, a byproduct recovered in the processing of sour (hydrogen sulphide) gas from fields in western Canada.

Nepheline Syenite and Feldspar

G.H.K. PEARSE

Nepheline syenite is a white to whitish-grey, medium-grained igneous rock resembling granite in texture. It consists of nepheline, potash and soda feldspar, and accessory mafic minerals such as biotite, hornblende and magnetite. Although nepheline syenite is a rock type known to occur in many parts of Canada, its industrial application is limited to those deposits from which iron-bearing accessory minerals can readily be removed; its major uses are in the glass and ceramics industries.

The use of nepheline syenite as a raw material for glass, ceramic and the filler industries was first developed in Canada, which was the world's sole producer for many years. Canada's only competitor in the field, Norway, began nepheline syenite mining and milling in 1961. Although the U.S.S.R. began mining nepheline syenite on the Kola Peninsula during the 1930s, the deposit was worked for its phosphate content. Byproduct nepheline from the Kola deposit became an important source of aluminum and is still being used for this purpose. Nepheline syenite is also quarried in the United States for use as aggregate, railway ballast, jettystone and roofing granules.

Canada's nepheline syenite industry began in 1932 with the staking of five claims on Blue Mountain, 25 miles northeast of Peterborough. A long period of persistent efforts in technical and market research and development was necessary before this unique industry became established. Today there are two mills in operation on Blue Mountain processing rock from several quarries.

Over the years nepheline syenite has become preferred to feldspar as a source of essential alumina and the alkalis in glass manufacture. Its use results in more rapid melting of the batch at lower temperatures than with feldspar, thus reducing fuel consumption, lengthening the life of furnace refractories and improving the yield and quality.

Industrial uses for nepheline syenite, other than for glass manufacture, include ceramic glazes, enamels, and filler in paints, papers, plastics and foam rubber.

Feldspar is the name of a group of minerals consisting of aluminum silicates of potassium, sodium and calcium. Feldspar is used in glassmaking as a source of alumina and the alkalis, in ceramic bodies and glazes, in cleaning compounds as a moderate abrasive and as a flux coating on welding rods. High-calcium feldspars, such as labradorite, and feldspar-rich rocks such as anorthosite, find limited use as building stones and for other decorative purposes. Dental spar, which is used in the manufacture of artificial teeth, is a pure white potash feldspar free of iron and mica.

Feldspar occurs in many rock types, but commercially viable deposits are mostly restricted to coarse-grained pegmatites from which the mineral is concentrated by flotation or, less commonly, by hand-cobbing. It is then ground to the desired size. Nearly all feldspar which has been produced in Canada has come from pegmatites in the Precambrian rocks of southern Ontario and southwestern Quebec.

Canadian production and developments

Nepheline syenite production comes from two operations on Blue Mountain in Methuen Township, Peterborough County, Ontario. The deposit is pear-shaped, approximately five miles long and up to one and one-half miles wide. The iron content of the rock is distributed quite uniformly but selective quarrying, blending of quarry material, and careful pit development are necessary to ensure a mill product capable of meeting consumer specifications. In general, the nepheline syenite zone is underlain by syenites and overlain by steeply dipping biotite schists. Nepheline syenite reserves are sufficient to satisfy demand for the foreseeable future.

Indusmin Limited, a subsidiary of Falconbridge Nickel Mines Limited, is the larger producer. The company's operation in Nephton, Ontario, was originally worked by its predecessor, American Nepheline Limited. Ore is currently being mined from five open pits. Rock is blasted from the pit face and loaded by electrically powered shovels into trucks for haulage to an adjacent mill at Nephton. The mill, which was built in 1956 and subsequently expanded to 1,000-tons-a-day capacity, operates three shifts a day, seven days a week, and produces several grades of nepheline

Table 1. Canada, nepheline syenite production, exports and consumption, 1974-1975

	1974		1975^p	
	(short tons)	($)	(short tons)	($)
Production (shipments)	617,279	9,179,453	520,000	8,663,000
Exports				
United States	469,241	7,216,000	380,368	6,625,000
Peru	320	9,000	1,626	171,000
United Kingdom	12,470	206,000	4,782	74,000
Australia	3,832	173,000	1,224	67,000
France	1,132	40,000	892	33,000
Italy	1,485	40,000	557	22,000
Israel	852	22,000	596	20,000
Belgium-Luxembourg	760	20,000	577	20,000
Other countries	3,748	120,000	1,759	71,000
Total	493,840	7,846,000	392,381	7,103,000
	1973	1974^p		
	(short tons)			
Consumption[1] (available data)				
Glass and glass fibre	66,148	71,957		
Whiteware	14,529	16,865		
Mineral wool	13,192	13,000^e		
Paints	6,546	3,531		
Porcelain enamel	260	257		
Others[2]	4,526	3,224		
Total	105,201	108,834		

Source: Statistics Canada.
[1]Total and breakdown from Mineral Development Sector, Department of Energy, Mines and Resources Ottawa. [2] Includes miscellaneous chemicals, gypsum products, rubber products, cleaners and detergents and other minor uses.
^{p}Preliminary; ^{e}Estimated

syenite to meet a wide variety of markets. The various grades produced are based on combinations of differing mesh sizes and iron content. Iron-bearing minerals are almost totally removed by electromagnetic methods. Finished products are transported by rail through Havelock, Ontario, 18 miles south of the mill, to domestic and exports markets. The United States accounts for as much as 75 per cent of Indusmin's sales.

A major expansion of the secondary milling circuit was postponed when sales dropped sharply in the last quarter of 1974 due to deteriorating economic conditions in the United States and Canada. However, installations can be completed within a few weeks when markets improve.

In 1974, ownership of International Minerals & Chemical Corporation (Canada) Limited's operation at Blue Mountain was transferred to Sobin Chemicals (Canada) Ltd. raising the former's interest in this company to 81 per cent from 37 per cent. The mill, located about four miles east of Indusmin's plant, was constructed in 1956 on a part of the deposit originally staked in 1932 by the Canadian Flint and Spar Company, Limited. Present capacity is 800 tons a day. The mill operates three shifts daily, seven days a week and produces a variety of products, based on mesh sizes and iron content, suitable, for many industrial uses. Rock is mined from an open pit adjacent to the mill; a certain degree of blending from various parts of the pit is required to ensure an acceptable mill feed. Ore reserves are sufficient for many years.

Sobin Chemicals' production is railed to Havelock, Ontario for distribution to various markets; up to 90 per cent being exported to the United States. The company produces three grades of nepheline syenite for glass, enamel, fibre and other applications.

In 1975, total nepheline syenite shipments amounted to 520,000 short tons valued at $8,663,000, a tonnage decrease of 16 per cent from 1974 and a value decrease of 6 per cent, reflecting price increases during the year.

From 1950 to 1962, annual shipments increased from 65,000 to 250,000 tons, an average growth rate of 17 per cent a year. Between 1963 and 1968 a growth rate of 9 per cent was realized. This dramatic growth was due largely to recognition by glassmakers of the superior properties, consistent quality, long-term reliable supply, and low cost of nepheline syenite, compared with feldspar. Between 1968 and 1974 average annual growth was 6 per cent. Deceleration in growth over the years has occurred as saturation of markets formerly held by feldspar has neared completion.

As a result of substitution by nepheline syenite, output of feldspar declined steadily from 55,000 tons in 1947 to 10,000 tons in 1961, a level that persisted throughout the 1960s and continues to be Canada's tonnage requirement. This competition led to closure of Canada's last feldspar producer, International Minerals & Chemical Corporation (Canada) Limited's Buckingham, Quebec mine in 1972. However, since closure, a shortage of potash feldspar, for which there is, as yet, no acceptable substitute in the manufacture of high-voltage electrical porcelain insulators, has developed in both the United States and Canada. Several local producers of high-value dental spar had delivered small tonnages to the mill at Buckingham until the recent closure. In 1974, one operation shipped several tons to Sweden and an enquiry for a possible several hundred tons, following assessment of a trial shipment, was received during 1975 from a North American manufacturer.

Table 2. Canada, nepheline syenite production and exports, 1965-1975[p]

	Production[1]	Exports
	(short tons)	
1966	366,696	263,624
1967	401,601	307,613
1968	426,595	323,182
1969	500,571	395,613
1970	486,667	387,947
1971	517,190	410,110
1972	559,483	442,470
1973	569,403	450,024[r]
1974	617,279	493,840
1975[p]	520,000	392,381

Source: Statistics Canada.
[1]Producer's shipments.
[p]Preliminary; [r]Revised.

Tantalum Mining Corporation of Canada Limited mines tantalum and lithium from a pegmatite containing abundant feldspar at Bernic Lake, Manitoba and the company is studying recovery and market potential of a clean quartz-feldspar product.

Other domestic occurrences

Nepheline syenite is known to occur in many localities in Canada but, to date, only the Blue Mountain deposit has proven amenable to economic mining and milling to produce material suitable for the glass and ceramic markets. Other occurrences are either too high in iron content or too variable in chemical composition to allow large-scale, open-pit development.

An extensive body of nepheline syenite outcrops in the Bancroft area of Ontario. Small tonnages of this material were mined from 1937 to 1942, but the product proved unacceptable because of considerable variation in the nepheline content and an overabundance of iron-bearing accessory minerals. Tontine Mining Limited (now Coldstream Mines Limited) discontinued exploration work in 1971 on a large nepheline syenite intrusive located near Port Coldwell, Ontario, after obtaining discouraging results from petrologic and metallurgical studies.

Nepheline syenite occurs in several localities in southern British Columbia, notably in the Ice River area, near Field, and in the Big Bend area on the Columbia River.

Nepheline is a common mineral constituent in the alkaline complexes of northern Ontario and southern Quebec, but none of these deposits are, as yet, of economic significance.

Feldspar is the major mineral constituent of pegmatite dykes which are widely distributed in Canada. Any large deposit near potential markets warrants investigation.

Markets

In 1975, 75 per cent of Canada's nepheline syenite output was exported. Sales to the United States decreased 19 per cent from 1974 and accounted for 97 per cent of total exports.

Canadian offshore sales were 12,000 short tons in 1975, about half that of 1974. All significant importers of Canadian nepheline syenite reduced their purchases in response to slackening demand.

Domestic shipments increased marginally to an estimated 127,000 tons in 1975 or 25 per cent of producers' shipments. Of this, about 60 per cent was used in glass and glass fibre manufacture.

In the glass industry, 15 to 20 per cent by weight of the glass batch is nepheline syenite. Material with a size range of minus 30 mesh to plus 200 mesh and with an iron content of less than 0.1 per cent is required in the production of flintglass. An iron content as high as 0.6 per cent, expressed as Fe_2O_3, is allowable for the manufacture of coloured glass. A typical chemical analysis for high-quality nepheline syenite produced in Canada for glass manufacture is:

Silica SiO_2	—	60.00
Alumina Al_2O_3	—	23.60
Iron Fe_2O_3	—	0.07
Lime CaO	—	0.30
Magnesia MgO	—	0.10
Potash K_2O	—	5.30
Soda Na_2O	—	10.20
Loss-on-ignition	—	0.50

A growing market is developing for finely ground material in the whiteware industry. The finer grades used for ceramic applications are produced by reducing the basic minus 30 mesh material in pebble mills. In ceramics, nepheline syenite is used as both a body and glaze ingredient. High-purity material in the minus 200 / plus 375 mesh size and with an iron content of 0.07 per cent Fe_2O_3 or less is most frequently used. Products utilizing this material include bathroom fixtures, vitreous enamels for appliances, china, ovenware, electrical porcelain and ceramic artwares.

Table 3. Canada, feldspar consumption, 1973-1974

	1973	1974
	(short tons)	
Consumption[1] (available data)		
Whiteware	6,099	7,155
Porcelain enamel	462	289
Soaps and cleaning compounds	—	—
Others[2]	417	103
Total	6,978	7,547

Source: Statistics Canada.
[1]Breakdown by Mineral Development Sector, Department of Energy, Mines and Resources, Ottawa. [2]Includes artificial abrasives, electrical apparatus, glass, paper and other minor uses.

Very finely ground material is being used increasingly as a filler in plastics, foam rubber and paints. Fine-grinding down to 10 microns is accomplished in pebble and fluid-energy mills. The very fine grain size, high reflectance and low oil absorption are important physical characteristics which make nepheline syenite an excellent filler material in such products as paints, vinyl, foam rubber and floor and wall tile.

A low-grade nepheline syenite is sold in bulk for use in the manufacture of fibre glass and for glazing on brick and tile. Some material with iron content is used in the manufacture of mineral wool and as an aggregate.

Substitution of alternative materials for feldspar in ceramic manufacture has been less severe than in the manufacture of glass. The principal reason is that raw materials costs are low in the ceramic industry in relation to total manufacturing costs and manufactures adopt a new raw material only after cautious trial use and extensive evaluation. Further, while the higher alumina content of nepheline syenite has been a decisive factor in the replacement of feldspar in glass manufacture, a high alumina content is less critical in ceramic manufacture. In ceramics, potash feldspar is used to bind the ceramic mix into what the industry terms a "body" and in the manufacture of electric porcelain for high voltage purposes this mineral is essential. The domestic market for feldspar appears to be firm at around 10,000 tons a year.

Table 4. Canada, feldspar production and consumption, 1966-1975

	Production[1]	Consumption
	(short tons)	
1966	10,904	8,528
1967	10,924	8,571
1968	10,394	7,343
1969	10,620	7,635
1970	12,385	7,540
1971	10,656	8,854
1972	10,774	9,724
1973	11,684	6,978
1974	—	7,547
1975	—	. .

Source: Statistics Canada.
[1]Producers shipments. 1966 exports 3,419 short tons, the last year for which exports were available.
[p]Preliminary; — Nil.

World review

The Norsk Nefelin Division of Christiania Spiegerwerk is western Europe's only producer of nepheline syenite. Operations at the plant near Hammerfest in northern Norway began in 1961 and increased steadily from an output of 23,000 metric tons in 1963 to 200,000 metric tons in 1973. The latest expansion, completed in 1973, raised capacity from 175,000 to 225,000 metric tons a year. The lenticular deposit is over one mile long and at least 750 feet deep. Unlike Canadian producers, Norsk Nefelin mines underground, drilling and blasting by conventional techniques. Nepheline syenite is supplied to the glass, ceramic and enamel industries in two main grades; glass grade is about 28 Tyler mesh and ceramic grade 200 Tyler mesh. The finer-mesh ceramic grade material is usually shipped in bags, whereas the coarser glass grade is shipped in bulk to European markets. The Company employs a modern fleet of coasters on long-term charter and ships finished products to storage and distribution centres in major market areas.

Nepheline syenite is an important source of alumina for aluminum production in the U.S.S.R. Very large deposits occur near Kirovsk in the Kola Peninsula and also in the Lake Baikal region of Siberia. The Kola deposits were first mined in the 1930s for phosphate. Byproduct nepheline that contains 30 per cent Al_2O_3 is recovered for use in aluminum production. In the process used to extract alumina, limestone is added to the nepheline concentrates and the mix is sintered and treated with caustic soda to yield anhydrous alumina, soda, potash and cement. Aluminum producers elsewhere in the world, faced with rising bauxite prices and concern for raw material supply, are viewing with interest potential alternate domestic sources of alumina, such as nepheline syenite and anorthosite.

Feldspar still retains a major share of its traditional markets outside of North America, although Norwegian nepheline syenite is rapidly making headway in these markets. World production of feldspar is an estimated 2.8 million short tons.

Outlook

The outlook for nepheline syenite continues to be good, although the current recession in the world economy interrupted growth. Housing starts were 4 per cent higher in Canada in 1975 relative to 1974 but still well below the 1973 level. This industry, of course, is a major consumer of glass, sanitary-ware, paint, etc. Canadian shipments to Europe and Australia, the two largest offshore markets for nepheline syenite, fell sharply. However, these account for less than 5 per cent of Canada's total sales and, therefore, have little effect on overall developments in the industry.

Over the last several years, the market for micronized material used as a filler and extender in plastics, paint, rubber and paper has grown more rapidly than consumption for glassmaking and further diversification and growth of these markets is expected.

Table 5. World production of feldspar, 1974-75

	1974	1975[e]
	(short tons)	
United States	854,000	775,000
West Germany	400,000	340,000
Norway	248,000	230,000
Italy	257,000	230,000
France	230,000	200,000
Japan	69,000	50,000
Sweden	31,000	25,000
Other Countries	1,085,000	950,000
Total	3,174,000	2,800,000

Source: U.S. Bureau of Mines Commodity Data Summaries, January 1976.
[e] Estimated.

The phenomenal growth rate enjoyed by the nepheline syenite industry during the 1950s and early 1960s has moderated as markets formerly supplied by feldspar approach saturation. The near-term hiatus in growth is a temporary one, and, with the recovery of the glass industry and continued expansion of other uses, a growth rate of 5 per cent a year is anticipated for the medium-term.

With increasing electrical energy requirements, the demand for essential feldspar, coupled with the decline in North American production, elevates this raw material to a position of prime importance. The present slackness in the economy has eased these pressures temporarily, but rising prices and growing markets could provide an opportunity to develop a suitable Canadian deposit in the near future.

Prices

Nepheline syenite prices vary from low-purity, crushed rock, in bulk, at about $6.00 a ton, to over $30.00 a ton for high-purity products. The price of nepheline syenite used in the glass industry is around $17.00 a ton fob plant. The largest export market is the United States, where entry is duty free.

Prices

United States feldspar prices in U.S. currency as quoted in *Engineering and Mining Journal,* December 1975.

(per short ton, f.o.b. mine or mill, carload lots, depending on grade).

	($)
North Carolina	
40 mesh, flotation	18.00-27.25
20 mesh, flotation	17.50
200 mesh, flotation	27.25-34.00
Georgia	
200 mesh	33.00
40 mesh, granular	26.00
Connecticut	
200 mesh	28.00-30.00
20 mesh granular	20.00-22.50

Tariffs

Canada

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
29600-1	Feldspar, crude	free	free	free	free
29625-1	Feldspar, ground but not further manufactured	free	7½%	30%	free
29640-1	Ground feldspar for use in Canadian manufacturers (July 1, 1974 to June 30, 1984)	free	free	30%	free

United States

Item No.		
522-31	Crude feldspar	free
522-41	Feldspar, crushed, ground or pulverized	3.5%

Sources: The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa. Tariff Schedule of the United States Annotated (1976) T.C. Publication 749.

Nickel

M.J. GAUVIN

Canadian production of nickel in 1975 decreased to 269,826* tons valued at $1,109.2 million from 296,600 tons valued at $994.6 million in 1974. World mine production is estimated at 790,446 tons in 1975 compared with 822,181 tons in 1974. During 1975 Canada, the world's largest producer of nickel, accounted for about 34 per cent of the world total. New Caledonia, with about 18 per cent of world production, and the U.S.S.R. with an estimated 17 per cent, were the two next largest producers.

The worldwide recession which started in the second half of 1974 resulted in one of the sharpest declines in nickel deliveries in the history of the industry. From the record delivery level of 610,000 tons in 1974, deliveries from metal producers in noncommunist countries dropped about 25 per cent to 465,000 tons in 1975. Major producers reduced their production levels during the year. New producers in the Philippines, Australia and Botswana all produced at levels much lower than expected as they experienced technical and mechanical startup problems. At the end of 1975 producer inventories were about three times normal and indications are that an oversupply situation will exist throughout 1976. Consumption of nickel in the noncommunist world in 1975 was about 450,000 tons. The comparable usage in 1974 was 605,000 tons.

There was a 19-cent-a-pound increase in the price of electrolytic nickel during 1975. The increase was announced at the end of August and became effective in December.

Canadian operations and developments

Six companies mined nickel ores in Canada during 1975. By far, the largest producer was The International Nickel Company of Canada, Limited (Inco) which operated mines in Ontario and Manitoba. Falconbridge Nickel Mines Limited, the second largest producer, treated ores from its mines located in the same provinces. Inco, Falconbridge and Sherritt Gordon Mines Limited each have integrated mine-concentrator-smelter and refinery complexes where they processed ore to the metal stage. The three other nickel concentrate producers are located in Ontario and Manitoba.

The International Nickel Company of Canada, Limited is the world's largest producer of nickel. Deliveries of nickel by Inco in 1975 were 175,500 tons, a drop of 36 per cent from the record year of 1974. Its production of nickel declined to 230,000 tons in 1975 from 255,000 tons in 1974. In Ontario, the company operated 12 mines, four concentrators, two smelters and a nickel refinery in the Sudbury district, a mine and concentrator at Shebandowan, northwestern Ontario and a nickel refinery and additive plants at Port Colborne. In Manitoba, Inco operated three mines, a concentrator, a smelter and a refinery at Thompson. In the Sudbury area work began on the development of a new mine, Levack East, where production is expected to begin in 1984. In Manitoba, work continued on deepening the Birchtree mine and on underground exploration at the Pipe mine. Three mines; the Totten and Murray in Ontario and the Soab in Manitoba, were maintained on a standby basis. The proven ore reserves of the company in Canada are 415 million tons containing 6.7 million tons of nickel and 4.3 million tons of copper.

Inco announced plans to build a plant in the Sudbury district for the direct rolling of metal powders to manufacture coinage strip. Construction of the $29 million facility is scheduled to begin early in 1976 and to be operational in the second half of 1977. Two new waste-water treatment plants went into operation at the end of the year to treat the bulk of the waste-water which is not recycled. Further refinements were made to the dust-recovery system at the Copper Cliff smelter.

Falconbridge Nickel Mines Limited operated eight mines, three concentrators and one smelter in the Sudbury area. In Manitoba, the company operated the Manibridge mine and concentrator. Concentrates produced at Manibridge are smelted at Inco's Thompson smelter. All nickel-copper matte produced at Falconbridge is shipped to the company's refinery at Kristiansand, Norway for treatment. A plant improve-

* The short ton of 2,000 pounds is used throughout unless otherwise stated.

ment program to improve the environment and operating efficiency at the refinery, started in 1974, is scheduled for completion in 1978.

At Sudbury, the company's operations were shut down by a 74-day strike which ended on November 2. At the end of the strike, operations were resumed at approximately 70 per cent of the pre-strike production level because of the worldwide reduced demand for nickel. As part of the curtailment, operations were suspended at three mines and one concentrator and one blast furnace in the smelter was shut down. Development work at the Lockerby mine was continued and at year-end the mine was producing 16,000 tons a month, 25 per cent of design capacity. It is scheduled to reach capacity in 1978. Construction work on a major smelter environmental improvement program was halted by the strike. Following the strike the program was deferred but plans call for work to be resumed in 1976. The program, which includes a new sulphuric acid plant, the replacement of the sinter plant by fluid bed roasters and replacement of the blast furnaces by electric furnaces, is expected to cost $97 million.

The third largest Canadian nickel producer is Sherritt Gordon Mines Limited. Sherritt Gordon operated its Lynn Lake, Manitoba nickel-copper mine and concentrator on a salvage basis. Production in 1975 fell below 1974 levels because of a shortage of miners. Lynn Lake concentrates are shipped to the Sherritt Gordon hydrometallurgical refinery in Fort Saskatchewan, Alberta. Nickel production of 27,937,000 pounds at the refinery was 7 per cent above 1974 production but well below capacity because of declining production at Lynn Lake and a shortfall in concentrate and matte from Australia. Sherritt has leased its nickel refining process to Western Mining Corporation Limited in Australia and to Impala Platinum Limited in South Africa. Marinduque Mining and Industrial Corporation in the Philippines is using Sherritt's process for production of metallic nickel from lateritic ores.

Table 1. Canada, nickel production, trade and consumption, 1974-75

	1974		1975^p	
	(short tons)	($)	(short tons)	($)
Production[1]				
All forms				
Ontario	230,440	749,782,101	199,440	815,934,000
Manitoba	65,401	222,232,448	70,386	293,296,000
British Columbia	759	2,579,480	—	—
Total	296,600	974,594,029	269,826	1,109,230,000
Exports				
Nickel in ores, concentrates and matte[2]				
United Kingdom	37,517	124,481,000	50,227	207,401,000
Norway	46,749	138,053,000	34,257	117,160,000
Japan	9,580	25,828,000	8,539	30,656,000
United States	115	163,000	2	5,000
Total	93,961	288,525,000	93,025	355,222,000
Nickel in oxide				
United States	36,118	90,376,000	18,209	63,541,000
Belgium-Luxembourg	8,547	21,653,000	7,678	28,789,000
Italy	1,459	3,648,000	5,897	21,697,000
United Kingdom	4,881	12,477,000	5,194	19,147,000
Sweden	1,338	3,401,000	1,853	6,714,000
West Germany	—	—	1,176	4,194,000
Spain	775	1,949,000	1,109	4,062,000
Other countries	3,230	9,787,000	1,352	5,189,000
Total	56,348	143,291,000	42,468	153,333,000

Table 1 (cont'd)

	1974		1975[p]	
	(short tons)	($)	(short tons)	($)
Nickel and nickel alloy scrap				
United States	2,568	5,277,000	1,418	3,629,000
Italy	186	574,000	880	2,377,000
France	–	–	254	535,000
South Korea	38	116,000	47	179,000
West Germany	110	389,000	294	145,000
Other countries	23	60,000	557	306,000
Total	2,925	6,416,000	3,450	7,171,000
Nickel anodes, cathodes, ingots, rods				
United States	83,047	256,874,000	75,289	279,472,000
United Kingdom	15,366	46,657,000	16,637	61,273,000
Japan	3,397	11,386,000	1,212	4,563,000
France	183	183,000	1,243	4,189,000
India	1,452	4,668,000	985	3,948,000
Australia	1,236	4,066,000	871	3,598,000
Brazil	1,097	3,705,000	715	2,929,000
Mexico	506	1,775,000	558	2,223,000
People's Republic of China	22,051	65,446,000	551	2,160,000
Netherlands	121	446,000	453	1,775,000
Argentina	554	1,949,000	326	1,339,000
Other countries	2,585	8,629,000	1,171	4,776,000
Total	131,595	405,784,000	100,011	372,245,000
Nickel and nickel alloy fabricated material, nes				
United States	7,124	22,949,000	8,094	30,929,000
United Kingdom	1,330	3,950,000	2,144	8,173,000
West Germany	92	366,000	85	448,000
Australia	204	636,000	97	424,000
Japan	57	247,000	74	326,000
Mexico	25	92,000	41	185,000
France	205	338,000	46	181,000
Other countries	763	2,384,000	168	737,000
Total	9,800	30,962,000	10,749	41,403,000
Imports				
Nickel in ores, concentrates and scrap				
Australia	1,700	4,920,000	9,566	29,168,000
United States	3,384	4,493,000	6,408	9,760,000
Japan	–	–	1,078	3,433,000
United Kingdom	5,203	4,077,000	2,368	2,102,000
Philippines	–	–	135	386,000
Belgium-Luxembourg	85	82,000	100	109,000
Other countries	1,398	3,230,000	86	116,000
Total	11,770	16,802,000	19,741	45,074,000

Table 1 (concl'd)

	1974		1975[p]	
	(short tons)	($)	(short tons)	($)
Nickel anodes, cathodes, ingots, rods				
Norway	16,615	58,789,000	12,457	51,676,000
United States	134	535,000	42	260,000
West Germany	32	162,000	29	168,000
Hong Kong	11	51,000	—	—
Total	16,792	59,537,000	12,528	52,104,000
Nickel alloy ingots, blocks, rods and wire bars				
United States	936	2,734,000	565	2,411,000
West Germany	—	—	5	27,000
Other countries	—	—	5	30,000
Total	936	2,734,000	575	2,468,000
Nickel and alloy plates, sheet, strip				
United States	3,702	17,489,000	2,863	19,360,000
United Kingdom	645	2,951,000	90	470,000
West Germany	86	382,000	52	425,000
Other countries	5	28,000	18	109,000
Total	4,438	20,850,000	3,023	20,364,000
Nickel and nickel alloy pipe and tubing				
United States	616	4,883,000	712	5,243,000
West Germany	2	15,000	228	3,449,000
Other countries	88	1,081,000	127	1,760,000
Total	706	5,979,000	1,067	10,452,000
Nickel and alloy fabricated material, nes				
United States	807	3,052,000	431	3,571,000
United Kingdom	142	517,000	102	629,000
West Germany	36	200,000	15	68,000
Other countries	15	69,000	10	73,000
Total	1,000	3,838,000	558	4,341,000
Consumption[3]	12,750	. .	. .	. .

Source: Statistics Canada.
[1]Refined nickel and nickel in oxides and salts produced, plus recoverable nickel in matte and concentrates exports. [2]For refining and re-export. [3]Consumption of nickel, all forms (refined metal and in oxide and salts) as reported by consumers.
[p] Preliminary; — Nil; . . Not available.

The Langmuir mine, near Timmins, Ontario, owned by Noranda Mines Limited and Inco, operated at capacity and increased its production 13 per cent above 1974 production. Ore reserves at the property are 857,500 tons grading 1.75 per cent nickel.

Kanichee Mining Incorporated continued mining from its open-pit operation near Temagami, Ontario, but at the end of the year it was notified that its smelter contract was being cancelled early in 1976.

Union Minière Explorations and Mining Corporation Limited (Umex) is developing and preparing for production its Thierry deposit near Pickle Crow, Ontario. Initial feed for the 4,000 ton-a-day concentrator will come from two open pits. Production is expected to start late in 1976. Current ore reserves, which are estimated at 15 million tons at 1.63 per cent copper, also contain a minor amount of nickel.

World developments

World mine production of nickel decreased from 822,181 tons in 1974 to an estimated 790,446 in 1975, a decrease of 4 per cent.

The Selebi-Pikwe project of Bamangwato Concessions Ltd. in Botswana continued to experience technical and operating difficulties and produced at only 15 per cent of its rated capacity of 40,000,000 pounds of nickel contained in matte a year. Further difficulties and delays are anticipated and full production is not expected until 1977. Ore is supplied to the plant from the Pikwe open-pit and underground mine. The Selebi

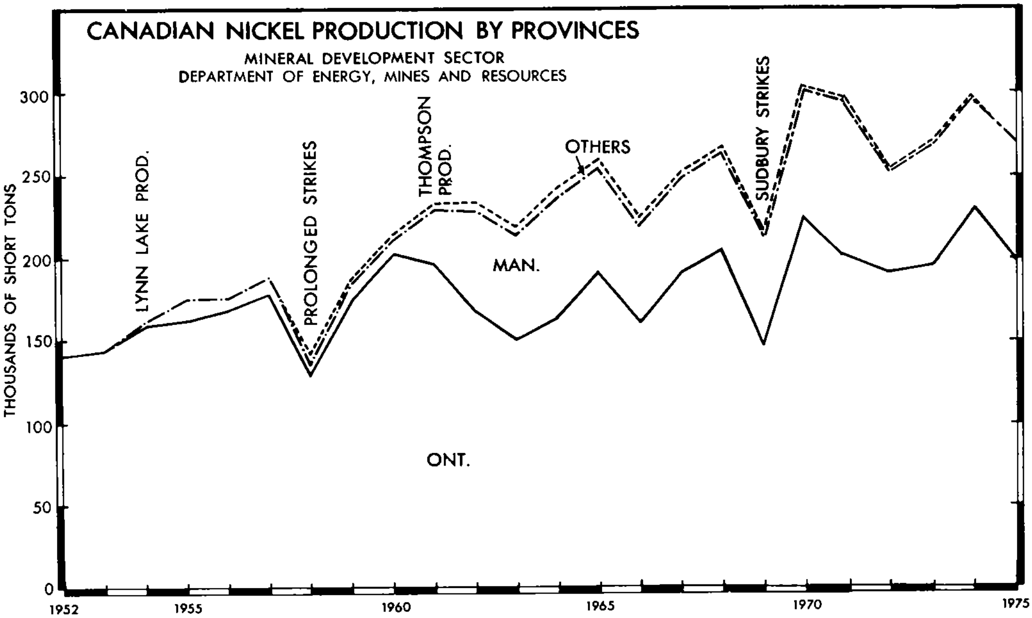


Table 2. Nickel production, trade and consumption, 1966-75

		Exports					
	Production[1]	In Ores; Concentrates and matte	In Oxide Sinter	Refined Metal	Total	Imports[2]	Consumption[3]
	(short tons)						
1966	223,610	83,586	33,631	132,712	249,929	28,916	8,608
1967	248,647	83,662	34,204	128,659	246,525	9,557	8,767
1968	264,358	95,527	42,058	127,095	264,680	11,394	11,233
1969	213,612	76,976	29,009	104,243	210,228	12,601	12,094
1970	305,881	96,659	43,895	153,203	293,757	11,826	11,794
1971	294,341	116,496	42,755	125,479	284,730	14,066	8,585
1972	258,987	114,799	36,646	120,123^r	271,568^r	18,000	10,187
1973	274,527	100,385	65,819	133,012^r	299,216^r	16,141	11,862
1974	296,600	93,961	56,348	131,595	281,904	16,792	12,750
1975^p	269,826	93,025	42,468	100,011	235,504	12,528	. .

Source: Statistics Canada.
[1]Refined metal and nickel in oxide and salts produced, plus recoverable nickel in matte and concentrates exported. [2]Refined nickel, comprising anodes, cathodes, ingots, rods and shot. [3]Consumption of nickel, all forms (refined metal, and in oxides and salts), as reported by consumers.
^{p} Preliminary; . . Not available; ^{r} Revised.

mine is scheduled to start production in 1979. The matte is refined at the Port Nickel, Louisiana refinery of AMAX Inc. The refinery, using an AMAX-developed acid leach process to produce nickel briquettes, has a capacity of 80 million pounds of nickel a year. Production in 1975, the first year of operation, was 16 million pounds of nickel. The refinery is expected to reach capacity in 1977.

Marinduque Mining and Industrial Corporation, in which Sherritt Gordon Mines Limited has a 10 per cent interest, produced its first refined nickel in December, 1974, at its new $242 million mine and refinery in the Philippines. This is the first refined nickel to be produced directly from laterite ores. The refinery utilizes the Sherritt Gordon hydrometallurgical process for refining nickel from laterite ores. Design capacity of the project is 68.4 million pounds of refined nickel in the form of briquettes and powder, plus mixed sulphide concentrates containing 6.6 million pounds of nickel and 3.3 million pounds of cobalt. Because of mechanical and design problems the refinery operated at an average of only 27 per cent of capacity during 1975. Rio Tuba Nickel Mining Corporation is preparing its Pulawan Island, Philippines, orebody for production in the summer of 1976 at the rate of 500,000 tons a year. Rio Tuba Nickel is a joint Philippine-Japanese enterprise owned 40 per cent by Pacific Metals Co. Ltd. of Japan.

The International Nickel Company of Canada Limited is developing two laterite projects. One of these is in Guatemala, where Inco, through Exploraciones y Explotaciones Mineras Izabal, S.A. (Exmibal) has started construction on the Lake Izabal laterite deposit. The plant will include a smelter with an annual capacity of 28 million pounds of nickel contained in a sulphide matte. Production is scheduled to start early in 1977. The project is owned 80 per cent by Inco and 20 per cent by The Hanna Mining Company, with provisions for the Guatemalan government and private Central American interests to eventually acquire up to 36 per cent of Exmibal. The estimated cost of the Exmibal project is $224 million. In Indonesia, P.T. International Nickel Indonesia continued construction on the first stage of development of the Malii-Soroaka deposits on Sulawesi Island which is expected to begin production late in 1976. Annual capacity of the first stage of the project will be 35 million pounds of nickel contained in a 75 per cent nickel matte. Financing has been arranged for the second stage which will include a hydroelectric plant on the Larona River and will increase nickel production capacity to 100 million pounds in 1978. Total cost of the completed project is now estimated at $820 million.

Falconbridge Dominicana C. por A., 65.7 per cent owned by Falconbridge Nickel Mines Limited, produces ferronickel at its property in the Yuna River Valley in the Dominican Republic. Deliveries in 1975 were 52.3 million pounds of nickel contained in ferronickel compared with 68.7 million pounds in 1974. Because of reduced demand, production was curtailed during the second half of the year.

The Australian Greenvale laterite-nickel project of Freeport Minerals Company and Metals Exploration N.L., that started up near the end of 1974, experienced mechanical and financial problems that interfered with production during 1975, but it is expected to reach full productive capacity during 1976. Greenvale has a rated capacity of 46 million pounds of nickel in the form of 90 per cent nickel oxide sinter, plus 7.5 million pounds of nickel and 2.7 million pounds of cobalt in the form of mixed sulphides. Ore reserves are estimated at 44 million tons averaging 1.57 per cent nickel. The start of construction at the Agnew deposit, also in Australia, has been postponed. Production from this development, owned by British Selection Trust and M-I-M Holdings Limited, is not expected before 1979. This $200 million mine and smelter project is expected to have an initial capacity of 30 million pounds a year of nickel in matte. Ore reserves are estimated at 40 million tons averaging 2.2 per cent nickel. Australia's largest producer, Western Mining Corporation, operates several mines and a concentrator at Kambalda, a smelter at Kalgoorlie and a refinery at Kwinana in Western Australia. Western Mining is the noncommunist world's fourth largest nickel producer and is in the process of increasing its refinery capacity from 22,000 to 33,000 tons of nickel a year. It also plans an expansion of its smelter from 39,000 to 72,000 tons a year.

The French government revoked the project license of Compagnie Française d'Entreprises Minières, Metallurgiques et d'Investissements (COFREMMI) in New Caledonia. COFREMMI, a subsidiary of Patino N.V., had started development of the Poum deposit. Changes at the end of the year in New Caledonia's tax system are expected to encourage development of the Island's nickel deposits. Société Métallurgique Le Nickel intends to increase the capacity of its Doniambo plant from 77,000 to 110,000 tons a year of nickel contained in ferronickel and matte by the early 1980's.

Table 3. Producing Canadian nickel mines, 1975 and (1974)

Company and Location	Mill or Mine Capacity	Grade of Ore: Nickel	Grade of Ore: Copper	Ore Produced	Contained Nickel Produced	Remarks
	(short tons ore/day)	(%)	(%)	(short tons)	(short tons)	
Quebec						
Société Minière d'Exploration Somex ltée Bickerdike Township, Lac Edouard	— (250)	— (1.5)	— (0.5)	— (52)	— (—)	Ore reserves exhausted
Ontario						
Falconbridge Nickel Mines Limited Falconbridge, East, Strathcona, Hardy Open Pit, Fecunis Lake Onaping, North, Longvac South Mines Falconbridge	14,000 (14,000) 3,000 8,400 2,600	. . (.) (Falconbridge) (Strathcona) (Fecunis Lake)	. . (.)	3,041,000 (4,336,652)	32,589[1] (46,798[1])	Operations shut down from August 21 to November 2 because of a strike. Major capital projects, with exception of Lockerby mine, temporarily suspended
The International Nickel Company of Canada, Limited Coleman, Copper Cliff North, Copper Cliff South, Crean Hill, Creighton, Frood-Stobie, Garson, Kirkwood, Levack, Levack West, Little Stobie, and Victoria mines Sudbury	65,000 (65,000) 35,000 11,400 24,000 6,000	1.40[2] (1.39)[2] (Clarabelle) (Creighton-not operating) (Frood-Stobie) (Levack)	0.92[2] (0.97)[2]	17,188,964[3] (18,021,305)[3]	175,560[4] (274,535)[4]	Development work on Levack East mine started, with production expected to start in 1984. Production at Victoria mine temporarily halted in 1975 and scheduled to resume late in 1976. Kirkwood mine expected to be mined out in first quarter, 1976
Shebandowan mine Shebandowan	2,500 (2,500)	. . (.)	. . (.)	see above[3] see above[3]	see above[4] see above[4]	
Kanichee Mining Incorporated Temagami	500 (500)	0.50 (0.49)	0.72 (0.72)	150,066 (122,451)	455 (215)	Smelter contract cancelled at end of year

Table 3. (concl'd)

Company and Location	Mill or Mine Capacity	Grade of Ore: Nickel	Grade of Ore: Copper	Ore Produced	Contained Nickel Produced	Remarks
	(short tons ore/day)	(%)	(%)	(short tons)	(short tons)	
Ontario (cont'd)						
Noranda Mines Limited Langmuir Township	700 (700)	1.46 (1.50)	. . . .	261,529 (212,699)	3,067 (2,606)	Mill operated at capacity during the year
Manitoba						
Dumbarton Mines Limited Maskwa East & West Extensions Bird River	— (—)	1.10 (0.72)	0.23 (0.30)	356,710 (326,378)	2,841 (1,700)	Ore trucked to the 1,200-ton-a-day Consolidated Canadian Faraday Limited concentrator
Falconbridge Nickel Mines Limited Manibridge Mine Wabowden	1,000 (1,000)	. . (. .)	. . (. .)	188,797 (183,758)	see above[1] see above[1]	
The International Nickel Company of Canada, Limited Birchtree, Pipe and Thompson mines Thompson	18,400 (18,400)	see above[2] (see above)[2]	see above[2] (see above)[2]	3,767,390 (3,767,202)	see above[4] see above[4]	Soab mine maintained on a standby basis. Underground exploration at the Pipe mine continuing
Sherritt Gordon Mines Limited Lynn Lake	3,500 (3,500)	0.84 (0.87)	0.38 (0.43)	351,536 (432,235)	2,866 (3,247)	Mine on salvage basis
British Columbia						
Giant Mascot Mines Limited Hope	— (1,800)	— (0.68)	— (0.21)	— (157,181)	— (770)	Mine closed August 1974

Sources: Company annual reports and data provided by companies.
[1]Total nickel deliveries, includes Manibridge; [2]Includes Manitoba division; [3]Includes Shebandowan; [4]Total nickel deliveries.
. . Not available; — Nil.

Table 4. Prospective[1] Canadian nickel mines

Company and Location	Mill Capacity[2] and Ore Grade	Year Production Expected	Destination of Nickel Concentrates	Remarks
	(%)			
Quebec				
Renzy Mines Limited Hainault Township	1,000 Ni (0.69) Cu (0.72)	. .	. .	Surface buildings destroyed by fire in 1974 will have to be rebuilt.
Ontario				
Falconbridge Nickel Mines Limited, Falconbridge	. . Ni (. .) Cu (. .)		Falconbridge	
Fraser mine		. .		
Lockerby mine		1975		Development work continuing. Full design capacity expected to be reached in 1978.
Thayer Lindsley mine		. .		Deferred.
Onex mine		. .		Deferred.
The International Nickel Company of Canada, Limited Sudbury	. . Ni (. .) Cu (. .)		Sudbury	
Clarabelle mine		. .		Open-pit mining completed in 1974. Mining will be resumed upon development of ore extension.
Murray mine		. .		Suspended and placed on standby in 1971.
Totten mine		. .		Development suspended and placed on standby in 1972.
Great Lakes Nickel Limited, Pardee Township	106,000,000 tons ore reserves Ni (0.20) Cu (0.40)			The development work to bring the property into production at a rate of 1.8 million tpy has been suspended and the project put on standby.
Union Minière Explorations and Mining Corporation Limited, Pickle Lake Thierry mine	4,000 Ni (. .) Cu (1.63)	1976	. .	Underground development continuing. Stripping operations started for open-pits that will supply initial mill feed. Surface construction in progress.
Manitoba				
The International Nickel Company of Canada, Limited Thompson, Soab mine	— Ni (. .) Cu (. .)	. .	Thompson	Production suspended and placed on standby in 1971.

Sources: Company annual reports and technical press.
[1]Mines with announced production plants. [2]Mill capacity in tons of ore a day.
. . Not available; — Nil.

Table 5. Nickel exploration projects

Company and Location	Indicated ore (tons)	Grade of ore (%)		Remarks
Quebec				
Dumont Nickel Corporation, Launey Township	15,500,000	0.646	(Ni)	Metallurgical test work and development work has been suspended.
Expo Ungava Mines Limited, Ungava	18,500,000	0.47 0.52	(Ni) (Cu)	
New Quebec Raglan Mines Limited, Ungava	16,050,000	2.58 0.71	(Ni) (Cu)	No work was carried out on the property in 1975.
Ontario				
The International Nickel Company of Canada, Limited Sudbury Cryderman North Range and Whistle mines	. .	. . . .	(Ni) (Cu)	
Manitoba				
Bowden Lake Nickel Mines Limited, Waboden				
Bowden Lake mine	80,000,000	0.60	(Ni)	Development work has been suspended on these deposits.
Bucko Lake mine	30,000,000	0.78	(Ni)	
Saskatchewan				
National Nickel Ltd. and Cadillac Explorations Limited,	5,476,000	0.34 0.18	(Ni) (Cu)	Open-pit reserves.
Nemeiben Lake, La Ronge	1,754,500	0.38 0.70	(Ni) (Cu)	Underground reserves.

Sources: Company annual reports and technical press.
. . Not available.

Uses

Nickel uses have not changed appreciably from the traditional pattern. Resistance to corrosion, high strength over a wide temperature range, pleasing appearance and suitability as an alloying agent are the chief advantages in almost all the uses of nickel.

Stainless steel is the largest single outlet for nickel, followed by nickel plating and high-nickel alloys. Stainless steel use has increased in the field of rapid transit and railway car manufacture, in fertilizer and food processing machinery, in petroleum refining and in architectural applications. High-nickel alloys are used in chemical, marine, electronic, nuclear and aerospace applications.

New end-use markets which will contribute to nickel's consumption growth are nuclear generating plants, gas turbine engines for surface applications, cryogenic containers, pollution abatement equipment and barnacle-resisting copper-nickel alloy hull-plating for boats.

Table 6. World production of nickel, 1974-75

	1974	1975
	(short tons)	
Canada[1]	296,000	269,826
New Caledonia	149,914	138,230
U.S.S.R.	132,277[e]	132,277[e]
Australia	60,076	72,091
Cuba	40,234	40,345
Dominican Republic	34,392	34,392
South Africa	24,361	22,928
Greece	16,645	15,763
Indonesia	17,637	14,881
United States	13,999	14,550
Rhodesia	12,677	12,125
Finland	6,614	6,283
Brazil	2,866	2,866
East Germany	2,425[e]	2,425[e]
Other	11,464[e]	11,464[e]
Total	822,181	790,446

Sources: World Bureau of Metal Statistics, March 1976. Statistics Canada, for Canada.
[1] Production all forms, [e] Estimated.

Outlook

By the end of 1975 the economies of the major nations had begun to recover from the severe recession the world had experienced during the year. Indications are that the recovery will be slow and that it will be well into 1977 before there is a balance between supply and demand. Producers' stocks are expected to remain high during 1976. New producers that have come on stream are improving their efficiency and increasing production. Several new producers as well as expansions of capacity will be operational by 1980. This new capacity will supply the expected growth of nickel markets into the early 1980's.

Looking further into the future, a possible nickel shortage is developing. There is not enough new capacity scheduled for production to satisfy the long-term growth of nickel markets. Capital costs of a new integrated plant are now over $8.00 a pound and current nickel prices do not justify this investment. Over the long-term, nickel prices must rise sufficiently to allow the new capacity to be built.

Prices

There was one change in the price of nickel during 1975. At the beginning of the year, refined nickel was quoted at $2.01 a pound and Class II (ferronickel and oxide sinter) was quoted in a price range of $1.88 to $2.01 a pound depending on the product and producer. In 1975, due to market conditions, some price discounting by producers was evident.

In late August and early September, producers announced price increases that became effective in December. The new prices increased the price of electrolytic nickel by 19 cents a pound and most Class II nickel by 17 cents.

Table 7. Prospective world nickel producers

Country Company Mine	Annual Capacity	Announced Date of Production	Destination of Concentrates	Remarks
	(tons of contained nickel)			
Australia				
Selcast Exploration Limited and Metals Exploration N.L., Mount Keith, Western Australia	..	..	..	Metals Exploration is studying feasibility of this project.
Selection Trust Limited and M-I-M Holdings	15,000	..	own smelter	Construction of mine, smelter and town has been postponed.
Agnew deposit Western Australia				

Table 7 (cont'd).

Country Company Mine	Annual Capacity	Announced Date of Production	Destination of Concentrates	Remarks
	(tons of contained nickel)			
Brazil				
Cia Vale do Rio Doce Piaui State	6,000	. .	own smelter	
Baminco Mineracao e Siderurgia, S.A. and Inco, and West German consortium. Barro Alto deposit Goias State	. .	. .	. .	Feasibility study in progress.
Columbia				
The Hanna Mining Company, Compania Niquel Chevron and Industrial Development Institute of Columbia. Cerro Matoso deposit	25,000	. .	. .	Pilot plant tests and feasibility studies to be completed.
Cuba				
Cuban government Cuban deposits	33,000 66,000	1975-1980 1980-1985	own smelter own smelter	Three new plants each with a capacity of 33,000 tpy to be brought into production between 1975 and 1985.
Greece				
Intercontinental Mining and Abrasives, Inc. and Southland Mining Company Lake Ionina	. .	. .	. .	
Larco Larymna area	36,000	. .	. .	Expansion of current capacity of 18,000 tpy.
Guatemala				
Exploraciones y Explotaciones Mineras Izabal, S.A. (Exmibal) Lake Izabal	14,000	1977	own smelter	
India				
Hindustan Copper Ltd., Sukinda deposit Orissa State	4,800	1979	own smelter	
Indonesia				
P.T. Aneka Tambang Pomalea Sulawesi Island	4,000	1976	own smelter	Ferronickel plant

Table 7 (concl'd)

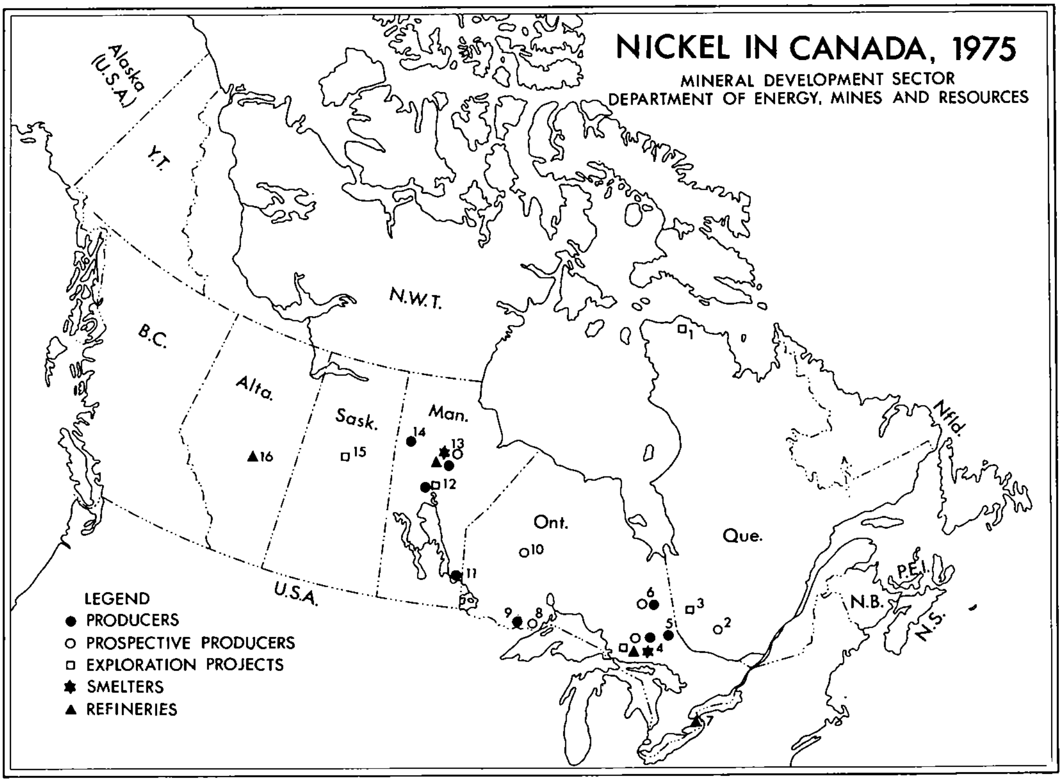
Country Company Mine	Annual Capacity	Announced Date of Production	Destination of Concentrates	Remarks
	(tons of contained nickel)			
P.T. International Nickel Indonesia Soroako deposit Sulawesi Island	17,500	1976	own smelter	Capacity to be expanded to 50,000 in 1978.
P.T. Pacific Nikkel Indonesia Gag Island Irian Barat	50,000	. .	own smelter	
Indonesia Nickel Development Company Gebe and Halmahera Islands	5,000	. .	own smelter	
New Caledonia				
Société Métallurgique Le Nickel	90,000	1980	own smelter	The Doniambo plant is being expanded from 77,000 tons and a further expansion to 100,000 tons is planned.
AMAX Inc. and Société Minière et Métallurgique de Penarroya, S.A. (Penamax) Goro deposit	25,000	. .	Port Nickel, Louisiana, U.S.A.	
Puerto Rico				
Universal Oil Products Co. Guanajibo deposit	15,000	. .	. .	In feasibility stage
Republic of the Philippines				
Atlas Consolidated Mining and Development Palawan Island	17,500	. .	own smelter	
Rio Tuba Nickel Mining Palawan Island	10,000	1976	Japan	Annual shipments of 500,000 tons of garnierite ore.
Venezuela				
Société Le Nickel and Venezuelan Government Loma de Hierro	20,000	. .	own smelter	
Yugoslavia				
Government company Kavadarci deposit Macedonia	12,000	1979	own smelter	Ferronickel
Golos and Cikatovo deposits Kosovo	10,000	1978	own smelter	Ferronickel

Sources: Company annual reports and technical press.
. . Not available.

Table 8. Producer prices for nickel quoted during 1975

	January	Price after price changes August — September
	(U.S. dollars per pound)	
Falconbridge Nickel		
Electrolytic, fob Thorold, Ont., 20,000 lb lots	$2.01	$2.20
Ferronickel[1]	2.01	2.18
The International Nickel Company of Canada, Limited		
Electrolytic, fob Port Colborne, Ont.	2.01	2.20
Nickel Oxide sinter 75[1]	1.88	2.07
"F" shot	2.07	2.23
Pellets	2.01	2.20
Sherritt Gordon		
Briquettes or powder, fob Niagara Falls, Ont. and Fort Saskatchewan, Alta. 20,000 lb lots	2.01	2.20
The Hanna Mining Company		
Ferronickel[1]	1.97	2.16
Société Métallurgique Le Nickel		
Rondelles	2.01	2.20
FNC[1]	2.00	2.17
FN3[1]	2.02	2.19
FN4[1]	1.98	2.15
Western Mining Corporation Limited		
Briquettes or powder	1.85	2.20

Sources: *The Northern Miner, Metals Week, American Metal Market.*
[1]Price applies to nickel content.



Producers

(numbers appear on accompanying map)

4. Falconbridge Nickel Mines Limited (East, Falconbridge, Fecunis Lake open-pit, Longvack South, North Onaping and Strathcona mines)
   The International Nickel Company of Canada, Limited (Clarabelle, Coleman, Copper Cliff North, Copper Cliff South, Cream Hill, Creighton, Frood-Stobie, Garson, Kirkwood, Levack, Levack West, Little Stobie, and Victoria mines)
5. Kanichee Mining Incorporated (Temagami)
6. Noranda Mines Limited (Timmins)
9. Inco (Shebandowan mine)
11. Dumbarton Mines Limited (Bird River)
12. Falconbridge Nickel Mines Limited (Manibridge mine)
13. Inco (Birchtree, Pipe and Thompson mines)
14. Sherritt Gordon Mines Limited (Lynn Lake)

Prospective Producers

2. Renzy Mines Limited (Hainault Township)
4. Falconbridge Nickel Mines Limited (Fraser, Lockerby, Onex and Thayer Lindsley mines)
   Inco (Clarabelle mine, Murray and Totten mines)
6. Texmont Mines Limited (Timmins)
8. Great Lakes Nickel Limited (Pardee Township)
10. Union Minière Explorations and Mining Corporation Limited (Pickle Crow)
13. The International Nickel Company of Canada, Limited (Soab mine)

Nickel Exploration Projects

1. New Quebec Raglan Mines Limited (Ungava) and Expo Ungava Mines Limited (Ungava)
3. Dumont Nickel Corporation (Launay Township)
4. Inco (Cryderman, North Range and Whistle mines)
12. Bowden Lake Nickel Mines Limited (Bowden Lake and Bucko Lake mines)
15. National Nickel Ltd. and Cadillac Explorations Limited (Nemeiben Lake)

Smelters

4. Falconbridge Nickel Mines Limited (Falconbridge)
   The International Nickel Company of Canada, Limited (Sudbury)
13. The International Nickel Company of Canada, Limited (Thompson)

Refineries

4. The International Nickel Company of Canada, Limited (Sudbury)
7. The International Nickel Company of Canada, Limited (Port Colborne)
13. The International Nickel Company of Canada, Limited (Thompson)
16. Sherritt Gordon Mines Limited (Fort Saskatchewan)

Tariffs

Canada

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
		(%)	(%)	(%)	(%)
32900-1	Nickel ores	free	free	free	free
33506-1	Nickelous oxide	10	15	25	10
35500-1	Nickel and alloys containing 60% or more nickel by weight, not otherwise provided for, viz: ingots, blocks, and shot; shapes or sections, billets, bars and rods, rolled, extruded or drawn (not including nickel processed for use as anodes); strip, sheet and plate (polished or not); seamless tube	free	free	free	free
35505-1	Rods containing 90% or more nickel, when imported by manufacturers of nickel electrode wire for spark plugs, for use exclusively in manufacture of such wire for spark plugs in their own factories	free	free	10	free
35510-1	Metal alloy strip or tubing, not being steel strip or tubing, containing not less than 30% by weight of nickel and 12% by weight of chromium, for use in Canadian manufactures	free	free	20	free
35515-1	Nickel and alloys containing 60% by weight or more of nickel, in powder form	free	free	free	free
35520-1	Nickel or nickel alloys, namely: matte, sludges, spent catalysts and scrap and concentrates other than ores	free	free	free	free
35800-1	Anodes of nickel	free	free	10	free
37506-1	Ferronickel	free	5	5	free
44643-1	Articles of nickel or of which nickel is the component material of chief value, of a class or kind not made in Canada, when imported by manufacturers of electric storage batteries for use exclusively in manufacture of such storage batteries in own factories	10	10	20	6½
92934-2	Nickel carbonyl, in liquid form, for use in the manufacture of moulds of nickel (expired Oct. 31, 1975)	free	free	25	free

Tariffs (concl'd)

United States

Item no.		On and after January 1, 1975
419.70	Nickel chloride	5%
419.72	Nickel oxide	free
419.74	Nickel sulphate	5%
419.76	Other nickel compounds	5%
423.90	Mixtures of two or more inorganic compounds in chief value of nickel oxide	free
426.58	Nickel salts: acetate	5%
426.62	Nickel salts: formate	5%
426.64	Nickel salts: other	5%
601.36	Nickel ore	free
603.60	Nickel matte	free
607.25	Ferronickel	free
620.03	Unwrought nickel	free
620.04	Nickel waste and scrap	free
620.08	Nickel plates and sheets, clad	12%
620.10	Other wrought nickel, not cold worked	5%
620.12	Other wrought nickel, cold worked	7%
620.16	Nickel, cut, pressed or stamped to nonrectangular shapes	9%
620.20	Nickel rods and wire, not cold worked	5%
620.22	Nickel rods and wire, cold worked	7%
620.26	Nickel angles, shapes and sections	9%
620.30	Nickel flakes	5¢ per lb.
620.32	Nickel powders	free
620.40	Pipes, tubes and blanks, not cold worked	3%
620.42	Pipes, tubes and blanks, cold worked	4%
620.46	Pipe and tube fittings	9%
620.47	If Canadian article and original motor vehicle equipment	free
620.50	Electroplating anodes, wrought or cast, of nickel	5%
642.06	Nickel wire strand	7%
657.50	Articles of nickel, not coated or plated with precious metal	9%

Sources: For Canada, the Customs Tariff and Amendments, Revenue Canada, Customs and Excise Division, Ottawa. For United States, Tariff Schedules of the United States Annotated (1976) TC Publication 749.

The International Nickel Company of Canada Limited's mine and smelter at Thompson, Manitoba. (Photo by George Hunter)

Petroleum

W.G. LUGG

For most sectors of the Canadian petroleum industry, 1975 was not a good year. Production of crude oil and natural gas liquids declined for the second consecutive year and exploratory activity in all regions was down from 1974 levels. A federally-regulated reduction in crude oil exports to the United States accounted for much of the production decline. Consumption from domestic supply was also down, primarily because of the stoppage in flow of western Canadian oil into areas east of the Ottawa valley as oil supply patterns returned to normal. Imports to eastern Canada from offshore suppliers increased.

Regardless of production cutbacks, revenue from sales of crude oil, natural gas liquids and natural gas reached an all-time high of $6,262 million. The large revenue increase relates to the July 1 rise in the posted price of crude oil as well as natural gas price increases. Netback to producers increased to a lesser degree, however, as increased royalty payments and taxes absorbed much of the production revenue increase. Expenditures for exploration and development were higher; expenditures in 1975 totalled $4,112 million compared with $3,394 million in 1974. Most of the expenditures were made in Alberta.

Exploration was probably the most depressed industry activity in 1975, an area where not only increased effort is needed but positive results must be attained as well if Canada is to maintain a high degree of oil self-sufficiency. No major discoveries of either oil or gas were made in the established areas, and exploration success in the frontier areas did not live up to expectations, particularly in the Mackenzie Delta area where results earlier had been most encouraging. Some success was attained in the Arctic islands where a significant oil discovery appears to be shaping up on Cameron Island. In the offshore east-coast area, the success attained in 1974 apparently was not maintained in 1975, although there are indications that two wells drilled late in the year had encountered significant occurrences of hydrocarbons. The full potential of these discoveries will await further evaluation during the limited drilling season in the summer of 1976.

Refinery capacity was increased substantially in Canada during the year with the addition of a major new refinery in western Canada and expansion of existing plants in eastern Canada. Imperial Oil Limited completed construction of its 140,000 b/d barrels a day Strathcona plant near Edmonton. The plant commenced operating in mid-1975 but start-up problems kept output below rated capacity.

Pipeline construction again decreased in 1975 and most of the decline was recorded in the large-diameter category.

Outlook

The long-term outlook for the Canadian oil and gas producing industry is not favourable, due primarily to a marked slowdown in locating and developing new supplies. Recent exploration in the frontier areas has been generally disappointing, particularly in respect to oil, and development of the Athabasca tar sands has proceeded at a slower pace than previously predicted. Canada is presently a net importer of oil, and in the absence of new large discoveries, our dependence on foreign supplies will increase through the late 1970's and early 80's. Prospective supplies that might come from frontier areas are estimated to be not sufficient to eliminate our dependence on imported oil prior to 1990.

In the event that synthetic oil from the tar sands and oil and gas from the frontier areas do not become available shortly, considerable strain could be felt by Canada's economy, since oil and gas are expected to continue to be the major energy used in Canada for the foreseeable future. There are indications that development of indigenous resources should be proceeding at a faster pace. There is no immediate danger of serious shortfalls in supplies of either oil or gas. Production of crude oil in 1976 will likely decline again as the legislated reduction in exports to conserve reserves is continued.

In the short term, it is anticipated that there will be an upturn in exploration activity in 1976, particularly in Alberta and British Columbia. The return to traditional areas to explore for oil and gas at the expense of frontier areas became evident during the latter stages of 1975. The reasons for this appear to be twofold: prospects of improved netbacks to producers resulting from increased prices and less-onerous royalties and taxes, and secondly, the staggering cost of drilling in frontier areas coupled with the long time differential between initial exploration and payout. Many oil companies are transferring exploration funds to southern areas where the rewards may not be as great but operating costs are much less.

Production of crude oil and natural gas liquids is expected to decrease by 6.5 per cent in 1976 to 1,623,000 b/d. Imports will continue to exceed exports, largely as a result of lower levels of crude oil exports to the United States. The regulated cutback in exports will be partially offset by higher Canadian demand, particularly after deliveries begin to the Montreal market through the Sarnia-Montreal pipeline extension. The export level will approximate 460,000 b/d in 1976 compared to 719,000 b/d in 1975, as exports are gradually reduced to 385,000 b/d during the year to allow for deliveries to Montreal refineries. Domestic demand for crude oil and equivalent will average about 1,008,000 b/d, 130,100 b/d more than in 1975. This depends on the assumptions that an average of 110,000 b/d flows into the Montreal market, starting at mid-year, and the Petrosar Limited plant takes an average of 65,000 b/d for the last two months of the year.

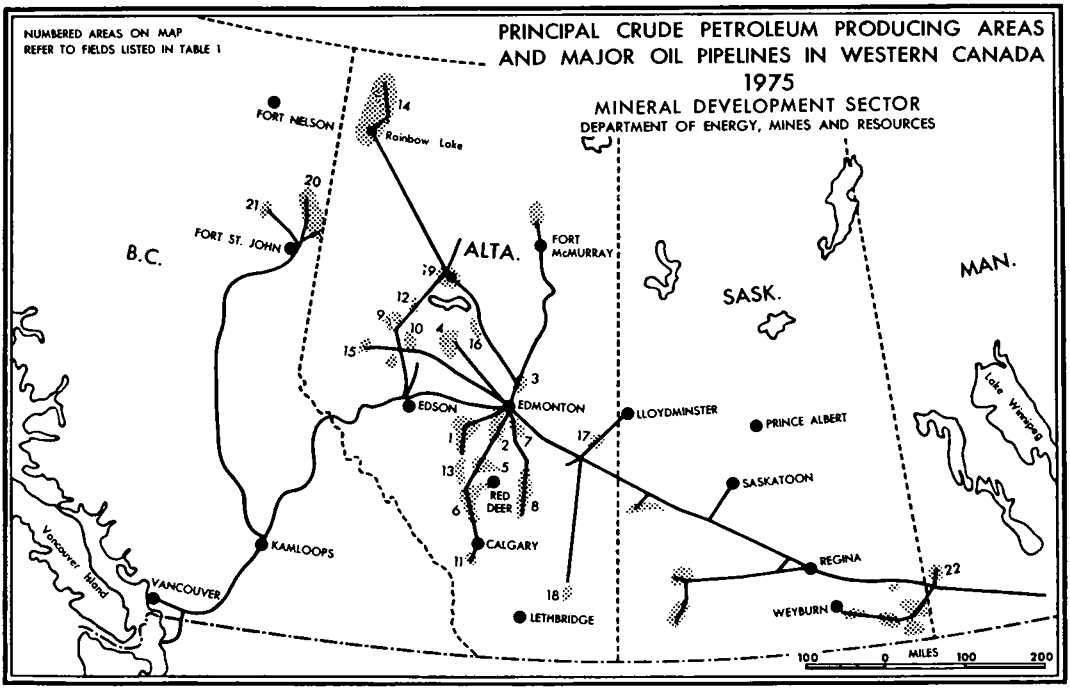


Table 1. Production of crude oil and condensate by province and field, 1974-1975^p

(Number in parentheses gives location of field on accompanying map)

	1974		1975^p	
	(barrels)	(bbl/day)	(barrels)	(bbl/day)
Alberta				
Swan Hills (4)	44,072,243	120,746	43,198,014	118,351
Pembina (1)	41,380,516	113,371	35,480,454	97,207
Redwater (3)	44,252,099	121,239	30,228,890	82,819
Rainbow (14)	34,017,441	93,199	29,247,158	80,129
Judy Creek	31,586,883	86,539	24,532,590	67,213
Swan Hills South (4)	20,011,920	54,827	22,731,578	62,278
Bonnie Glenn (2)	30,619,597	83,889	19,573,926	53,627
Mitsue (16)	17,162,154	47,020	17,651,319	48,360
Nipisi (19)	19,894,730	54,506	15,545,476	42,590

Table 1 (cont'd)

Alberta (cont'd)	1974 (barrels)	1974 (bbl/day)	1975^p (barrels)	1975^p (bbl/day)
Wizard Lake (2)	18,884,351	51,738	14,902,064	40,828
Golden Spike (2)	18,826,469	51,579	11,007,101	30,156
Fenn Big Valley (8)	10,356,674	28,374	9,340,005	25,589
Virginia Hills	8,817,429	24,157	7,725,273	21,165
Carson Creek North (4)	8,383,475	22,968	7,376,115	20,209
Leduc-Woodbend (2)	7,906,614	21,662	6,917,045	18,951
Sturgeon Lake South	1,568,147	4,296	6,077,167	16,650
Willesden Green (13)	5,060,515	13,864	5,332,807	14,610
Kaybob (10)	5,355,813	14,674	4,999,686	13,698
Westerose (2)	6,534,892	17,904	4,985,311	13,658
Provost	3,386,825	9,279	3,888,920	10,655
Countess	4,624,456	12,670	3,873,368	10,612
Harmattan East (6)	4,693,856	12,860	3,656,878	10,019
Innisfail (6)	3,929,612	10,766	3,445,494	9,440
Zama (14)	4,878,637	13,366	3,314,245	9,080
Rainbow South (14)	3,854,129	10,559	3,245,538	8,892
Kaybob South (10)	4,653,787	12,750	3,052,465	8,363
Joarcam (7)	3,043,363	8,338	2,812,647	7,706
Medicine River (13)	2,592,741	7,103	2,763,409	7,571
Snipe Lake	2,661,713	7,292	2,719,345	7,450
Harmattan Elkton (6)	2,668,339	7,311	2,647,300	7,253
Simonette (15)	3,095,067	8,480	2,606,437	7,141
Bellshill Lake	3,060,873	8,386	2,591,527	7,100
Wainwright (17)	2,402,072	6,581	2,450,303	6,713
Acheson (2)	4,651,472	12,744	2,382,417	6,527
Clive	1,554,761	4,260	2,335,570	6,399
Goose River	1,986,494	5,442	2,132,359	5,842
Bantry (18)	2,127,933	5,830	2,006,518	5,497
Red Earth	2,310,113	6,329	1,982,227	5,431
Virgo (14)	2,297,982	6,296	1,934,193	5,299
Grand Forks	1,478,588	4,051	1,790,909	4,907
Gilby (5)	1,696,564	4,648	1,585,405	4,344
Lloydminster	1,089,947	2,986	1,518,683	4,161
Ferrier	1,573,265	4,310	1,461,639	4,005
Sundre	1,306,441	3,579	1,435,838	3,934
Twining	1,030,712	2,824	1,434,478	3,930
Stettler	1,552,657	4,254	1,355,348	3,713
Joffre (5)	1,410,479	3,864	1,292,451	3,541
Boundary Lake South	1,261,095	3,455	1,275,823	3,495
Utikuma Lake	1,536,044	4,208	1,216,189	3,332
Meekwap	1,091,297	2,990	1,188,484	3,256
St. Albert Big Lake	1,466,553	4,018	1,161,873	3,183
Turner Valley	1,109,482	3,040	1,097,808	3,008
Cessford	1,163,855	3,189	1,083,641	2,969
Sylvan Lake	1,130,485	3,097	1,051,326	2,880
West Drumheller	1,279,577	3,506	1,044,147	2,861
Taber South	1,233,062	3,378	991,699	2,717
Hussar	1,156,998	3,170	964,946	2,644
Excelsior	1,061,087	2,907	802,939	2,200
Drumheller	1,093,837	2,997	744,551	2,040
Cyn-Pem	1,139,518	3,122	602,171	1,650
Other fields and pools	49,409,270	135,368	43,357,513	118,788
Total	515,437,000	1,412,156	441,151,000	1,208,633
Total Value ($)	2,985,549,000		3,216,961,000	

Table 1. (concl'd)

	1974		1975[p]	
	(barrels)	(bbl/day)	(barrels)	(bbl/day)
Saskatchewan[1]				
Total	73,947,000	202,595	59,162,000	162,088
Total Value ($)	397,835,000		396,388,000	
British Columbia				
Boundary Lake (20)	7,619,642	20,876	5,586,206	15,305
Peejay	2,787,828	7,638	1,982,606	5,432
Inga (21)	2,309,995	6,329	1,609,569	4,410
Milligan Creek (20)	1,753,706	4,805	1,376,817	3,772
Weasel	1,194,432	3,272	902,556	2,473
Other fields and pools	3,282,397	8,993	2,920,246	8,001
Total	18,948,000	51,912	14,378,000	39,393
Total Value ($)	103,501,000		94,896,000	
Manitoba				
North Virden Scallion (22)	2,322,519	6,363	2,160,375	5,919
Virden-Roselea (22)	1,209,891	3,315	1,156,440	3,168
Other fields and pools	1,216,590	3,333	1,097,185	3,006
Total	4,749,000	13,011	4,414,000	12,093
Total Value ($)	27,164,000		31,466,000	
Ontario				
Total	734,000	2,011	700,000	1,918
Total Value ($)	4,342,000		5,039,000	
Northwest Territories				
Total	954,000	2,614	1,006,000	2,756
Total Value ($)	3,167,000		3,525,000	
New Brunswick				
Total	8,000	22	7,000	19
Total Value ($)	11,000		9,000	
Canada				
Total	614,777,000	1,684,321	520,818,000	1,426,900
Total Value ($)	3,521,569,000		3,748,284,000	

Source: Provincial government reports and Statistics Canada.
[1]Saskatchewan lists production by formation rather than by field.
[p]Preliminary.

Reserves

According to the Canadian Petroleum Association (CPA), Canada's proven liquid hydrocarbon reserves, which include conventional crude oil and natural gas liquids (propane, butane and pentanes plus), amounted to 8.2 billion barrels at the end of 1975. This is comprised of 6.6 billion barrels of crude oil and 1.6 billion barrels of natural gas liquids. These estimates do not include oil in the Athabasca tar sands. At the 1975 annual production level of 618 million barrels, the life index for conventional crude oil and natural gas liquids rose from 12 to 13.2 years. The rise is not because of an increase in proven reserves, but rather because of reduced producing rates. Reserves added in 1975 totalled 56.6 million barrels and of this amount, 20.4 million barrels were attributable to revisions, 31.5 million barrels to extensions of established fields and only 4.6 million barrels to new discoveries.

Reserves in most provinces declined; the most notable reduction being in Alberta where year-end reserves were 626 million barrels less than the year earlier. The CPA estimated Alberta's remaining recoverable reserves of crude oil at 5.7 billion barrels and natural gas liquids at 1.5 billion barrels. Together, these

Table 2. Production of natural gas liquids by province, 1974-75ᵖ

	1974		1975ᵖ	
	(000' barrels)	(bbl/day)	(000' barrels)	(bbl/day)
Alberta				
Propane	32,025	87,739	33,775	92,534
Butane	21,210	58,109	22,007	60,294
Pentanes Plus	56,713	155,378	53,118	145,529
Condensate	911	2,496	739	2,024
Total	110,859	303,722	109,639	300,381
Saskatchewan				
Propane	625	1,713	560	1,534
Butane	265	726	239	655
Pentanes Plus	195	535	171	469
Condensate	160	438	157	430
Total	1,245	3,412	1,127	3,088
British Columbia				
Propane	562	1,540	516	1,412
Butane	663	1,817	669	1,834
Pentanes Plus	1,123	3,076	1,165	3,193
Condensate	104	285	101	277
Total	2,452	6,718	2,451	6,716
Canada				
Propane	33,212	90,992	34,850	95,480
Butane	22,138	60,652	22,916	62,783
Pentanes Plus	58,031	158,990	54,454	149,190
Condensate	1,175	3,219	997	2,732
Total	114,556	313,853	113,217	310,185
Returned to formation	98	269	88	241
Total net production	114,458	313,584	113,129	309,944

Source: Provincial government reports.
ᵖPreliminary.

accounted for about 88 per cent of Canada's proven reserves. Saskatchewan's reserves of liquid hydrocarbon increased from 573 million barrels to 680 million barrels in 1975. The increase is not attributable to any new discoveries, extension or infill drilling. Rather, it is mainly due to revisions of estimates of recoverable reserves in three of the larger fields where enhanced recovery facilities had been installed some years ago.

Natural gas liquids from recently-discovered gas fields in the Mackenzie Delta are included in the estimates but oil from the frontier regions is not, chiefly because insufficient data precludes any meaningful estimate.

Commencing in 1975 the CPA adopted new procedures for estimating oil sands reserves. Synthetic crude oil reserves associated with each plant are calculated on the basis of the plant's rated output capacity over a 25-year period; the 25 years being indicative of a reasonable economic life for the facilities. New projects are recognized by the CPA three years prior to the scheduled start-up date of each such project. Based on this method, the CPA estimates the remaining proved developed non-conventional crude oil reserves at the end of 1975 at 1.5 billion barrels. These estimates are not to be confused with published estimates of approximately 250 billion barrels which are believed to be recoverable from Athabasca-type oil sands by mining or in-situ processes.

Production

Canadian production of crude oil and natural gas liquids declined by 13 per cent in 1975. Average production of crude oil, including synthetic oil from the Athabasca tar sands and natural gas liquids, totalled 1,734,000 b/d compared with 1,994,700 b/d in 1974. Crude oil production, including synthetic crude oil, declined by 257,000 b/d to 1,424,000 b/d. Synthetic crude oil production at 43,189 b/d declined by 3,000 b/d. Natural gas liquid production decreased by 3,600 b/d to 310,000 b/d, consisting of 152,000 b/d of pentanes plus and condensate, and 158,000 b/d of propane and butane. Alberta's crude oil production declined by 203,000 b/d and accounted for 85 per cent of total Canadian output. Saskatchewan's crude oil production at 162,000 b/d was down 40,000 b/d from 1974 production levels and accounted for 11 per cent of the Canadian total. British Columbia's production declined to 39,000 b/d and represented 3.0 per cent of total national production. Manitoba accounted for 0.8 per cent and Ontario and the Northwest Territories together, 0.2 per cent. All provinces except the main producers, namely Alberta and Saskatchewan, were producing at capacity.

In tar sands development, the Syncrude Canada Ltd. project is on schedule and was 20 per cent complete at the end of 1975. Target date for first production is early 1978 at an initial rate of 52,000 b/d of synthetic crude oil. This is expected to be doubled in 1979 and then to gradually be increased to 125,000 b/d to allow for the installation of additional equipment currently being planned to overcome some anticipated problems. Syncrude expects to produce more than one billion barrels of synthetic crude oil from its lease.

Because of the extremely high capital costs of tar sands extraction plants at the present time, most of the companies which were prospective early developers have not proceeded with project plans. However, Shell Canada Limited has carried out long and extensive research into both the technical and economic factors involved in constructing and operating a tar sands plant and are strong contenders for a future plant. Petrofina Canada Ltd. is also showing continuing interest in tar sands development.

In respect to other unconventional oil recovery projects, Imperial Oil Limited's Leming pilot project is operating successfully at Cold Lake and should soon be progressing from the experimental phase to a production of 5,000 b/d. The Leming pilot plant was designed on the basis of Imperial's experience in its Ethel pilot research project operated between 1964 and 1970, and its May project which was started in 1972. All of these field plants were designed to test the feasibility of recovering the heavy oil by steam stimulation techniques because oil in the Cold Lake reservoir cannot be recovered by conventional production methods due to its high viscosity. Currently, the $15 million Leming pilot project consists of 56 wells centred around a steam generating plant. To bring production up to 100,000 b/d would require 10,000 wells and a plant capable of generating steam from 500,000 b/d of water. The cost of such a facility is estimated to be as high as $2.5 billion.

Table 3. Value of natural gas liquids 1974-75p

	1974	1975p
	($ thousands)	
Alberta	634,802	748,063
Saskatchewan	6,201	5,878
British Columbia	12,559	13,825
Total	653,562	767,766
Volume (000 barrels)	113,304	110,468

Source: Statistics Canada.
p Preliminary.

Exploration and development

Alberta. Although exploratory drilling footage was less in 1975 than in 1974, development drilling increased, but this was due largely to increased industry activity in developing the shallow gas-producing trends in southeastern Alberta. Drilling statistics show development drilling increased 5.6 per cent to 7.2 million feet and exploratory drilling was down 8 per cent to 4.8 million feet. Aggregate drilling in the province declined slightly despite a major upsurge in exploration for, and development of, provincial natural gas resources.

There were several oil discoveries in Alberta but preliminary analysis suggests that most of them are not significant. Possibly the most significant of these was a discovery in the Otter Lake area of northwestern Alberta, about 11 miles west of the Red Earth field. A well drilled by Coseka Resources Limited tested oil from the Keg River-Granite Wash interval, which is the producing interval at the Red Earth field. However, the previous history of Red Earth type discoveries suggests that although there may be an abundance of undiscovered oil in the region, it is difficult to find; and once found, is difficult to develop because of the irregular distribution of the reservoir rock. Nevertheless, this discovery has sparked an upsurge of industry activity in the region.

In the Swalwell area of south-central Alberta, a dual-zone oil success was completed by a team of three companies headed by Czar Resources Ltd. Production was obtained from the Pekisko and Shunda formations of Mississippian age and the company recently staked a follow-up test about one mile north of the discovery, which in turn directly offsets the field limits of the Swalwell oil field. Farther north in central-west Alberta, Dekalb Petroleum Corporation made a discovery one-half mile north of the northern field boundary of the Willesden Green oil field. Due to confidentiality, details of the discovery have not been divulged, but there is a possibility that the successful well represents an extension of the Willesden Green field rather than a new discovery.

Table 4. Canada, crude oil production, trade and refinery receipts, 1965-75

	Production	Imports[1]	Exports[1]	Refinery Receipts[2] Domestic	Refinery Receipts[2] Imports	Refinery Receipts[2] Totals
			(barrels)			
1965	296,418,914	144,184,281	108,010,297	208,581,343	144,000,656	352,581,999
1966	320,542,794	146,076,898	123,691,342	220,196,625	158,546,823	378,743,448
1967	351,292,332	170,784,980	150,344,567	224,569,817	163,148,797	387,718,614
1968	379,396,276	177,738,586	167,487,968	236,178,376	177,293,134	413,471,510
1969	410,989,930	193,124,846	197,340,741	242,034,744	190,479,081	432,513,825
1970	461,180,059	207,633,062	240,893,633	258,966,344	208,339,853	467,306,197
1971	492,739,049	244,971,778	270,770,498	263,239,168	244,224,822	507,463,990
1972	561,976,934	281,664,159	341,252,881	273,238,175	288,754,232	561,992,367
1973	655,853,110	327,428,510	420,059,984	300,123,924	311,292,150	611,416,074
1974	614,777,000	291,155,897	332,216,272	347,509,716	299,282,910	646,792,626
1975[p]	520,818,000	298,237,573	262,455,079	320,495,992	300,687,596	621,183,588

Source: Statistics Canada.
[1]Trade of Canada (SC) data. [2] Includes condensate and pentanes plus.
[p]Preliminary.

In the Caroline area of western Alberta, and adjacent to the Foothills Belt, three discoveries were made in what was reported to be the Viking sandstone. Although it is too early to determine the significance of the discoveries, the operating company, Dome Petroleum Limited, has reported that the three wells are indicated commercial producers. All of the discoveries are adjacent to the Caroline oil field and could be either major extensions of this field or a new producing trend. It will not be known which until the well data is removed from the confidential list.

Although most of the development drilling was within the boundaries of established producing fields, a major extension to the Joffre, Viking sandstone oil field was made by Republic Resources Limited. The operating company has completed 10 successful development wells on the southern boundary of the field and is now drilling the 11th well. The Joffre field, discovered in 1953, produced about 34 million barrels in the 18-year period between 1953 and 1971. This latest round of drilling has extended the producing life of the field, which had been considered almost completely depleted in 1971. Also in south-central Alberta, major extensions to the Twining and Provost fields were established. Several companies pursued an active development program in the Wainwright heavy oil region of eastern Alberta and successfully enlarged the boundaries of both the Wildmere and Wainwright fields. However, the recent soft market for heavy-gravity crude oil has discouraged further development drilling in this area. Nevertheless, Husky Oil Ltd. has announced its intention to build a 30,000 b/d refinery in the Lloydminster area which is designed to produce a full range of products from heavy crude oil. This factor undoubtedly will provide further incentive for the exploration and development of the known substantial heavy oil resources of the region.

In 1975 there was renewed interest in developing Alberta's vast resources of heavy oil in the Cold Lake area of eastern Alberta. Among companies initiating pilot oil recovery projects in 1975 was Murphy Oil Company Ltd. With the approval of the Alberta Energy Resources Conservation Board (AERCB), their steam injection scheme commenced in July on their 2700-acre lease on the southern edge of the Cold Lake deposit. An estimated 150 million barrels of heavy oil is the target of their recovery scheme; none of this could be produced by conventional methods. The Cold Lake

Table 5. Canada, year-end reserves of crude oil, 1974-75

	1975	% of Total 1974	% of Total 1975	Net change 1975 over 1974
		(000 bbls)		
Alberta	5,748,923	88.6	86.4	−602,514
Saskatchewan	671,697	7.9	10.1	+105,432
British Columbia	146,487	2.2	2.2	−14,150
Northwest Territories	39,796	0.6	0.6	−999
Manitoba	36,508	0.6	0.6	−4,274
Eastern Canada	9,591	0.1	0.1	−1,722
Total	6,653,002	100.0	100.0	−518,227

Source: Canadian Petroleum Association.

sandstones contain one of the largest oil deposits in Canada, estimated by AERCB at 164 billion barrels of oil in place. Only a fraction of this oil is recoverable however, as it is too thick to pump and too deep to be mined by open cast mining methods. Nevertheless, it can make an important contribution to overall Canadian supply as production from existing conventional sources declines in the years to come.

Imperial Oil Limited has been one of the pioneers in Cold Lake oil sands development and to date has spent about $35 million since 1964 experimenting with potential extraction methods. Currently they are operating a 56 well steam-injection project. The steam is pumped into a well, heating the reservoir and thereby lowering the viscosity to allow it and the hot water to be pumped to the surface. Production from the pilot project is estimated to be 5,000 b/d which will be shipped to Imperial's new Strathcona refinery in Edmonton. A successful operation in the pilot stage could lead Imperial to expand this project into a large scale operation with an ultimate production level of 100,000 b/d.

Table 6. Canada, reserves of liquid hydrocarbons at end of 1975

	Natural Gas Liquids	Crude Oil Plus Natural Gas Liquids	% of Total
	(000 bbls)	(000 bbls)	
Alberta	1,519,363	7,268,286	88.2
Saskatchewan	8,152	679,849	8.3
British Columbia	35,683	182,170	2.2
Other areas	22,856	108,751	1.3
Total	1,586,054	8,239,056	100.0

Source: Canadian Petroleum Association.
— Nil.

Saskatchewan and Manitoba. Both the number of wells and footage drilled in Saskatchewan decreased slightly in 1975, remaining substantially well below levels recorded prior to 1974. Total footage amounted to 649,205 feet compared to 706,133 feet in 1974. The number of wells drilled numbered 267 compared to 288 in 1974 and, as in the previous year, a number of these were drilled by the Saskatchewan Oil and Gas Corporation (Saskoil), the provincial Crown corporation. Only one significant oil discovery was reported in Saskatchewan in 1975 and that was drilled by Dome Petroleum Limited five miles west of Estevan, Saskatchewan. The discovery is significant because it was made in the Winnipegosis formation, a deeper horizon than that from which the bulk of Saskatchewan's current oil production is obtained. Only limited details as to the status of the well have been released, but apparently the well is capable of commercial production. The discovery may be an indication of a new producing trend in Saskatchewan, something badly needed to revive the province's lagging oil production.

In Manitoba, both the number of wells and footages drilled declined substantially in 1975. Total footage amounted to only 21,938 feet as only 7 wells were drilled. Some successful development drilling was carried out in the Pierson field in southwestern Manitoba, slightly enlarging the field boundaries. No oil discoveries were made in the province during the year.

British Columbia. Both exploratory and development drilling decreased in 1975. Exploratory drilling amounted to 277,618 feet, 171,949 feet less than in 1974. Development drilling decreased by 166,868 feet to 143,929 feet. Almost all of the development drilling was confined to natural gas fields as there has not been a significant oil discovery made in British Columbia for several years and there was none in 1975.

Yukon Territory, Northwest Territories and Arctic Islands. In northern Canada there were 44 wells drilled in 1975 for a total footage of 371,450 feet compared with 60 wells and 503,227 feet in 1974. All but 10 wells were classed as exploratory resulting in one oil and three as gas discoveries; all of these were located in the Mackenzie Delta region.

Large scale exploratory effort in the Mackenzie Delta began in 1965. Since that time there have been several significant oil and gas discoveries. Prior to 1975, at least three gas discoveries and one oil discovery could be classified in the major field category. Despite the decline in drilling in 1975, a few new finds were made and successful "step-out" wells to previous discoveries added to their proven reserves. Early in 1975, Shell Canada Limited (Shell) drilled a one mile step-out to its original Niglintgak H-30 gas discovery well drilled in January 1973. The well encountered nine hydrocarbon-bearing sandstone zones totalling 500 feet. Five of the zones were gas-bearing and the remainder were oil-bearing. Preliminary estimates based on both well and seismic data place reserves of this field at about 1 trillion cubic feet of gas and about 80 million barrels of oil. Elsewhere on the Delta, Shell's Kumak J-06 well drilled in April, encountered both oil and gas below the 4000-foot level. A successful follow-up well was drilled later in the year 1½ miles from the discovery, and oil and gas flows were encountered in essentially the same horizons as the discovery. Indications are that the structure is very complex and additional drilling will be required before reserve estimates can be made. Late in the year, Sun Oil Company Limited announced that its well, Sun *et al* Gary P-04, drilled in the Mackenzie Delta had yielded hydrocarbons on drill stem tests of zones below 9700 feet. Substantial flows of both oil and gas were recorded. Full significance of the tests is yet to be determined and further testing of other potential zones is planned. The well was directionally drilled from a small island in the Beaufort Sea, a short distance from the mainland. Plans call for a follow-up well on the mainland as soon as the discovery rig can be moved across the ice.

Table 7. Canada, wells completed and footage drilled

	1955		1960		1974		1975^p	
	(no.)	(ft.)	(no.)	(ft.)	(no.)	(ft.)	(no.)	(ft.)
Western Canada								
Westcoast offshore								
New field wildcats	—	—	—	—	—	—	—	—
British Columbia								
New field wildcats	34	194,014	60	365,818	8	82,679	12	97,297
Other exploratory	2	13,020	11	55,749	78	366,888	36	180,321
Development	—	—	72	331,740	60	310,797	33	143,929
	36	207,034	143	753,307	146	760,364	81	421,547
Alberta								
New field wildcats	307	1,773,980	338	2,078,876	457	1,901,299	350	1,357,330
Other exploratory	105	436,941	223	1,171,079	933	3,285,526	1,033	3,423,718
Development	1,208	6,219,810	1,131	7,125,856	2,250	6,808,017	2,449	7,191,296
	1,620	8,430,731	1,692	10,375,811	3,640	11,994,842	3,832	11,972,344
Saskatchewan								
New field wildcats	312	1,182,727	113	468,507	78	210,484	55	156,785
Other exploratory	50	179,511	28	99,203	56	145,734	52	135,963
Development	550	1,873,040	461	1,795,968	154	349,915	160	356,457
	912	3,235,278	602	2,363,678	288	706,133	267	649,205
Manitoba								
New field wildcats	59	174,313	10	30,505	13	51,734	4	11,901
Other exploratory	10	23,743	3	6,370	1	3,519	—	—
Development	292	647,379	54	110,073	6	16,807	3	10,037
	361	845,435	67	146,948	20	72,060	7	21,938
Yukon and Northwest Territories & Arctic Islands								
New field wildcats	6	12,266	32	105,969	47	389,197	31	258,546
Other exploratory	—	—	—	—	9	83,703	3	24,833
Development	—	—	—	—	4	30,327	10	88,071
	6	12,266	32	105,969	60	503,227	44	371,450
Total Western Canada								
New field wildcats	718	3,337,300	553	3,049,675	603	2,635,393	452	1,881,859
Other exploratory	167	653,215	265	1,332,401	1,077	3,885,370	1,124	3,764,835
Development	2,050	8,740,229	1,718	9,363,637	2,474	7,515,863	2,655	7,789,790
	2,935	12,730,744	2,536	13,745,713	4,154	14,036,626	4,231	13,436,484
Eastern Canada								
Eastcoast offshore								
New field wildcats	—	—	—	—	19	185,352	9	86,330
Other exploratory	—	—	—	—	—	—	—	—
	—	—	—	—	19	185,352	9	86,330
Hudson's Bay offshore								
New field wildcats	—	—	—	—	2	9,511	—	—
Other exploratory	—	—	—	—	—	—	—	—
	—	—	—	—	2	9,511	—	—

Table 7 (concl'd)

	1955		1960		1974		1975[p]	
Eastern Canada (cont'd)	(no.)	(ft.)	(no.)	(ft.)	(no.)	(ft.)	(no.)	(ft.)
Ontario								
New field wildcats	64	112,246	39	68,393	51	103,435	49	94,447
Other exploratory	57	92,536	55	109,839	42	50,223	16	27,237
Development	266	271,191	213	228,190	61	88,187	73	93,869
	387	475,973	307	406,422	154	241,845	138	215,553
Quebec								
New field wildcats	9	10,226	5	4,287	6	27,705	3	9,963
Other exploratory	—	—	—	—	—	—	—	—
Development	—	—	1	240	—	—	—	—
	9	10,226	6	4,527	6	27,705	3	9,963
Atlantic Provinces								
New field wildcats	2	4,795	3	22,863	—	—	7	56,215
Other exploratory	—	—	—	—	—	—	—	—
Development	7	21,143	—	—	—	—	—	—
	9	25,938	3	22,863	—	—	7	56,215
Total Eastern Canada								
New field wildcats	75	127,267	47	95,543	78	326,003	68	246,955
Other exploratory	57	92,536	55	109,839	42	50,223	16	27,237
Development	273	292,334	214	228,430	61	88,187	73	93,869
	405	512,137	316	433,812	181	464,413	157	368,061
Total Canada								
New field wildcats	793	3,464,567	600	3,145,218	681	2,961,396	520	2,128,814
Other exploratory	224	745,751	320	1,442,240	1,119	3,935,593	1,140	3,792,072
Development	2,323	9,032,563	1,932	9,592,067	2,535	7,604,050	2,728	7,883,659
	3,340	13,242,881	2,852	14,179,525	4,335	14,501,039	4,388	13,804,545

Source: Canadian Petroleum Association.
— Nil; [p] Preliminary.

Offshore in the Beaufort Sea, Imperial Oil announced that a successful follow-up well had been drilled from an artificial island about three miles south of its original discovery, Adgo F-28, drilled the previous year. The new well encountered 250 feet of gas-bearing and 140 feet of oil-bearing reservoir between the 2,000- and 5,800-foot level. The reservoir rocks are reported to have excellent porosities, prompting speculation that this discovery may be Canada's first major offshore oil discovery. The geology of the Beaufort Sea is considered to be even more favourable for hydrocarbon accumulation than onshore, and industry's confidence in its ability to operate in this hostile environment has contributed to increasing optimism that their efforts will be rewarded by the discovery of major reserves. At year-end, plans were being made to extend the search to deeper waters in the Beaufort Sea where it is impossible to construct artificial islands by present technology. Two specially-constructed drillships are now being built for Dome Petroleum Limited. The drillships are designed to drill offshore during the summer season in from 90 to 2,000 feet of water. They are expected to be operational by the summer of 1976, and it is anticipated that the first well drilled will be on Dome's permit acreage, approximately 70 miles north of the Adgo artificial island.

In the Arctic Islands, no new significant finds of oil or gas were made in 1975, however, successful step-out drilling considerably enlarged the boundaries of three previously-discovered fields: two gas fields and one oil field. All three of these wells were drilled by Panarctic Oils Ltd., the industry-government consortium. On the east coast of the Sabine Peninsula, Melville Island, the Panarctic East Drake I-55 well established a major extension to the already sizeable Drake Point gas field. The well was drilled from an ice pad eight miles offshore and encountered a similar gas-bearing sandstone as other onshore tests in the same field. The length of the Drake Point field has now been established at over 25 miles and it can now be classified in the major gas field category. On the west side of the Sabine Peninsula, Panarctic completed a successful step-out well on the east flank of the Hecla field. The step-out well extends the known boundaries of the field three miles inland. The western limits of the Hecla field were extended last year by an offshore well drilled from an ice pad eight miles offshore. Although further drilling is contemplated in the winter to determine the ultimate limits of the field, it is apparent that the Hecla field is already in the major gas field category.

On Cameron Island, Panarctic drilled a successful step-out well about a mile away from its original discovery, Panarctic *et al* Bent Horn N-72, completed during the previous year. At that time, Panarctic suspected that the discovery well had penetrated the edge of an oil-bearing Devonian reef structure and seismic data indicated a substantial reef buildup updip from this well. The successful step-out, which yielded up to 30,000 b/d of good quality, crude oil on test, tended to confirm the indication and may have established the presence of the Arctic Islands' first major oil field.

Eastern Canada. Aggregate drilling in Ontario decreased in 1975 by 11 per cent to 215,553 feet. Exploratory drilling accounted for 56 per cent of the total, down 7 per cent from the previous year. Of these 8 were classified as gas discoveries — there were no oil discoveries. The gas discoveries were confined to Silurian, pinnacle reefs located along the eastern flank of the Michigan basin in Lambton County. There was one Devonian gas discovery by The Consumers Gas Company which was also responsible for the bulk of the exploratory and development drilling in Lake Erie. As in the previous year, most of the exploratory activity in Quebec was carried out by the Quebec Crown corporation, Quebec Petroleum Operations Company (SOQUIP). This year three wells were drilled in Quebec and all were exploratory. All three were unsuccessful.

Offshore from the east coast, both the number of wells and footage drilled declined. In 1975, nine wells were drilled for a total footage of 86,330 feet compared to 19 wells and 185,352 feet in 1974. All wells were in the exploratory category. The results of exploratory drilling on the Scotian Banks have been disappointing and, as a consequence, oil companies operating in the area are increasingly surrendering large blocks of their permit acreage. At the same time, Mobil Oil Canada, Ltd., in November, announced its intention to suspend for an indefinite period all exploration off the east coast of Canada. The company felt that before proceeding further it was necessary to make a careful study of the results of its offshore exploration program over the past ten years before formulating ongoing plans. Mobil is

Table 8. Wells drilled, by province, 1974-75

	Oil		Gas		Dry[1]		Total	
	1974	1975^p	1974	1975^p	1974	1975^p	1974	1975^p
Western Canada								
Alberta	651	670	1,719	1,958	1,270	1,204	3,640	3,832
Saskatchewan	71	105	126	85	91	77	288	267
British Columbia	6	2	47	31	93	48	146	81
Manitoba	5	2	—	—	15	5	20	7
Yukon and Northwest Territories & Arctic Islands	2	3	10	6	48	35	60	44
Westcoast offshore	—	—	—	—	—	—	—	—
Subtotal	735	782	1,902	2,080	1,517	1,369	4,154	4,231
Eastern Canada								
Ontario	4	4	60	68	90	66	154	138
Quebec	—	—	—	—	6	3	6	3
Atlantic provinces	—	—	—	—	—	4	—	7
Eastcoast offshore	—	—	—	—	19	9	19	9
Hudson's Bay offshore	—	—	—	—	2	3	2	—
Subtotal	4	4	60	68	117	85	181	157
Total Canada	739	786	1,962	2,148	1,634	1,454	4,335	4,388

Source: Canadian Petroleum Association.
[1]Includes suspended and abandoned wells.
^{p}Preliminary; — Nil.

Table 9. Oil wells in western Canada at end of 1974-75

	Producing Wells		Wells capable of Production	
	1974	1975	1974	1975
Alberta	10,395	10,708	14,819	15,177
Saskatchewan	6,271	6,073	7,663	7,675
Manitoba	714	657	871	844
British Columbia	519	459	694	696
Northwest Territories and Arctic Islands	32	37	59	59
Total	17,931	17,934	24,106	24,451

Source: Provincial and federal government reports.

one of the pioneers in offshore east coast exploration. During its ten years of operations it has drilled 26 wells, resulting in four separate discoveries — Sable Island, Thebaud, Cohasset and Citnalta — none of which are considered to be commercial at the present time.

Offsetting the drilling decline on the Scotian Shelf was the steadily-rising industry interest farther north, offshore from Labrador on the Labrador Shelf. In 1975, six wells were drilled in this area: five by self-positioning drillships and the other by a conventional type semi-submersible drilling rig; the latter of the type which has drilled most of the wells on the Scotian Shelf farther south. The self-positioning drillship has much more flexibility in moving on and off the drill hold in the event of an emergency, something which is a definite advantage when operating in an area which is prone to sudden violent storms and the hazards of drifting icebergs. Four of the six wells were drilled by Eastcan Exploration Ltd. and the remaining two by BP Canada Limited. Three of the six wells were dry, and were abandoned, the remaining three will not be completed this year because of the short drilling season. Company plans presently call for re-entering these holes and fully evaluating them during the 1976 summer drilling season. Of the three, two appear to be potential discoveries. The first of these, Eastcan Snorri J-90, was drilled to a depth of 10,531 feet during 1975, and suspended after encountering hydrocarbon shows. Eastcan Exploration Ltd., the operating company, decided it did not have time to adequately evaluate the well in the 1975 season but will run extensive tests on the prospective horizons some time in 1976. Farther north, Eastcan, in October 1975, announced that its well, Eastcan *et al* Karlsefni H-13, was drilled to a depth of 10,774 feet and suspended. Plans are to re-enter the well in 1976 and drill to the planned depth of 16,500 feet. The Karlsefni well, located about 880 miles north of St. John's, Newfoundland and offshore from the Labrador coast, encountered some indications of hydrocarobons below 7,500 feet. This is the northernmost well drilled to date on the Labrador Shelf.

In looking at the east coast, reference should be made to two significant discoveries made on the Labrador Shelf in 1974, both by a group of companies led by Eastcan Exploration Ltd. The first of these discoveries was made by the Gudrid H-55 well located about 500 miles north of St. John's Newfoundland, and the second, Bjarni H-81, is located about 80 miles north of the Gudrid wells. Although no further drilling was done on either of these discoveries in 1975, it is believed that they are both located on large structures and have excellent reservoir potential. At first sight it may appear that the outcome of the 1975 drilling season on the Labrador Shelf was disappointing but the final results of this drilling are still to be determined. It should also be pointed out that this is a vast exploration area and to date only 11 wells have been drilled to test its hydrocarbon potential. In any event, because of the physical hazards of operating in this area, it is certain that it will be a long and difficult task to discover and successfully produce oil and gas.

Transportation

Crude oil and product pipeline construction fell to the lowest level in several years as only 282 miles of new pipeline were put into operation. The lack of new oil discoveries and regulated cutbacks in crude oil production were responsible for the decline. Almost all of the construction was confined to medium and small-diameter line.

As in the previous year, Trans Mountain Pipe Line Company Ltd., one of the two major trunkline systems, operated well below capacity and because of this, confined its construction to minor modification of existing installations. Interprovincial Pipe Line Limited, the other major trunkline system, also operated below capacity and will likely continue to do so until its Sarnia-Montreal extension is completed late in 1976. This pipeline was the only major pipeline initiated in 1975. Laying of the 520-mile 30-inch line commenced in September and it is anticipated it will take about one

Table 10. Mileage in Canada of pipelines for crude oil, natural gas liquids and products

Year-end	Miles	Year-end	Miles[1]
1960	8,436	1958	14,832
1961	9,554	1969	17,075
1962	10,037	1970	17,062
1963	10,607	1971	17,837
1964	11,744	1972	18,310
1965	12,315	1973	18,732
1966	12,995	1974	19,425
1967	14,155	1975^p	19,707

Source: Statistics Canada.
[1]Includes producer gathering lines for 1969 to 1975.
^{p}Preliminary.

year to complete. The line will have a capacity of 350,000 b/d (initial throughput of 250,000 b/d) and is expected to cost $185 million. Fully powered with 16 pumping stations, the capacity of the line would approach 690,000 b/d and flow in the line can be reversed if necessary.

In Arctic oil pipeline planning, the Beaufort Delta-Oil Project Limited, a consortium of oil and pipeline companies, is still actively studying the feasibility of constructing a crude oil pipeline from the Mackenzie Delta-Beaufort Sea area to tie in with existing crude oil pipeline systems in Alberta. The members of this consortium are Gulf Oil Canada Limited, Imperial Oil Limited, Shell Canada Limited, Inter-provincial Pipe Line Limited and Trans Mountain Pipe Line Company. Pending results of exploratory drilling in the Mackenzie Delta this winter, the company hopes to apply early in 1977 for federal regulatory approval of its planned Mackenzie River Valley crude oil pipeline. The company estimates that such a pipeline would require about 1.5 billion barrels of proven oil reserves. The cost of a 200,000 b/d pipeline would be about $2 billion. The pipeline tariff would approximate $6 a barrel.

In regard to future projects, Trans Mountain Pipe Line Company Ltd., which now operates a 780-mile crude oil pipeline system originating in Edmonton, Alberta and running to refineries in British Columbia and Washington State, is studying the feasibility of building a pipeline from Saint John, New Brunswick to Buffalo. The study is in a preliminary stage and several routes are being assessed. A similar study was done in December 1972 by Ashland Oil Canada Limited and New England Petroleum Corporation who completed preliminary studies for a 600-mile line from a deep water port, to be located about 130 miles east of Quebec City, to Buffalo. A 42-inch line on the south shore of the St. Lawrence to Montreal was planned, with a smaller line through New York State to Buffalo. This project has been inactive since the preliminary study.

Table 11. Deliveries of crude oil and propane by company and destination, 1974-75

Company and Destination	1974	1975
	(millions of barrels)	
Interprovincial Pipe Line		
Western Canada	56.9	50.1
United States	228.6	187.1
Ontario	191.6	186.2
Total	477.1	423.4
Trans Mountain Pipe Line		
British Columbia	44.5	44.9
State of Washington	73.7	65.4
Westridge terminal	19.2	4.3
Total	137.4	114.6

Source: Company annual reports.

Petroleum refining

Canadian refinery capacity increased by 60,000 b/d in 1975 to 2,083,000 b/d, primarily due to the addition of Imperial Oil Enterprises Ltd.'s large new refinery near Edmonton, Alberta. Other refinery growth was restricted to minor expansions to existing plants. The number of refineries operating in Canada was reduced to 38 at the end of 1975 as four refineries in western Canada were shut down.

Table 12. Crude oil refining capacity by regions

	1974		1975	
	(bbl/day)	(%)	(bbl/day)	(%)
Atlantic provinces	414,500	20.5	415,800	20.0
Quebec	646,600	32.0	644,100	30.9
Ontario	522,700	25.8	540,300	25.9
Prairies and Northwest Territories	296,400	14.7	332,700	16.0
British Columbia	143,100	7.0	150,100	7.2
Total	2,023,300	100.0	2,083,000	100.0

Source: Department of Energy, Mines and Resources, *Petroleum Refineries in Canada* (Operators List 5), January 1976.

In Nova Scotia, refinery expansion in 1975 was confined to a minor increase in Gulf Oil Canada Limited's Point Tupper refinery. In New Brunswick, Irving Oil Limited is expected to complete the expansion of its refinery at Saint John by mid-1976. When construction is finished, the capacity of the plant will be 250,000 b/d, more than double its current capacity of 120,000 b/d and making it the largest refinery in Canada. The planned construction of two large refineries by Shaheen Natural Resources Company Inc. — a 200,000 b/d facility on Canso Strait in Nova Scotia, the other a 300,000 b/d plant at Come-By-Chance adjacent to its present plant, will now not likely take place. It was intended that these plants would serve the export market in northeastern United States and Europe; however, a number of factors, including a softening in demand for petroleum products in these areas, combined with a growing refinery overcapacity elsewhere in Canada, has postponed the need for additional refineries.

In Quebec, Imperial Oil Enterprises Ltd. is expected to complete the $40 million modernization of its Montreal plant by mid-1976, while Shell Canada Limited intends to install a 20,000 b/d reformer at its Montreal East refinery this year. In Ontario, Gulf Oil completed the 16,700 b/d expansion of their Clarkson

Table 13. Canada, crude oil received at refineries, 1974 and 1975[p]

Location of Refineries		Country of Origin							
		Canada	Middle East	Trinidad	Venezuela	Africa	Colombia	Other	Total Received
Atlantic provinces	1974	3,836,785	83,183,797	—	36,407,091	—	106,949	7,398,767	130,933,389
	1975	38,011	84,602,028	578,437	29,695,870	401,416	—	193,139	115,508,901
Quebec	1974	23,417,074	70,882,086	—	91,552,160	7,588,899	231,007	1,864,532	195,535,758
	1975	2,436,050	104,542,404	188,357	64,176,866	12,785,479	—	3,226,098	187,355,254
Ontario	1974	165,494,791	—	—	67,622	—	—	—	165,562,413
	1975	161,400,654	—	—	297,502	—	—	—	161,698,156
Prairies	1974	101,565,868	—	—	—	—	—	—	101,565,868
	1975	104,283,439	—	—	—	—	—	—	104,283,439
British Columbia	1974	52,218,908	—	—	—	—	—	—	52,218,908
	1975	51,344,794	—	—	—	—	—	—	51,344,794
Northwest Territories and Yukon	1974	976,290	—	—	—	—	—	—	976,290
	1975	993,044	—	—	—	—	—	—	993,044
Total	1974	347,509,716	154,065,883	—	128,026,873	7,588,899	337,956	9,263,299	646,792,626
	1975	320,495,992	189,144,432	766,794	94,170,238	13,186,895	—	3,419,237	621,183,588

Source: Statistics Canada.
[p]Preliminary; — Nil.

refinery during the year. Other refinery expansions in Ontario were relatively minor, the largest being a 20,000 b/d increase in the rated capacity of Shell Canada Limited's Oakville plant. However, construction of Texaco Canada Limited's 95,000 b/d Nanticoke plant on the north shore of Lake Erie is proceeding on schedule and the plant should be completed by the end of 1977. Currently the largest refinery complex under construction in Ontario is the Petrosar Limited's petrochemical refinery in Sarnia. The Petrosar facility is scheduled to come on stream in 1977 and when fully operational will produce 35,500 b/d of petrochemicals and 115,300 b/d of petroleum products including synthetic gas, motor gasoline and home heating and residual fuel oils.

On the Prairies, Imperial Oil's Strathcona refinery near Edmonton was completed in early 1975 and is now operating at half capacity. This 140,000 b/d refinery will likely be up to maximum throughput by mid-year at which time it will have on stream a 5,000 b/d heavy oil distillation unit, designed to process Cold Lake crude oils. Imperial converted their smaller refineries in Winnipeg, Regina and Calgary into petroleum product distribution centres when the Strathcona plant came on stream. Elsewhere in Alberta, Husky Oil Ltd. announced plans to build a 30,000 b/d refinery near Lloydminster, Alberta which will use heavy oil produced in the area and will be designed to produce a full range of products. The new facility is scheduled to be on stream in mid-1978 and will use units from Mobil Oil Canada, Ltd.'s 50,000 b/d refinery in East St. Louis, Illinois which Husky purchased late in 1974. In Regina, Consumers' Co-operative Refineries Limited commenced construction to raise the capacity of its refinery from 27,000 b/d to 50,000 b/d. Expansion of other refineries in the Prairie provinces were relatively minor, the largest being a 1,950 b/d increase in the capacity of Gulf's Calgary refinery.

In British Columbia, Pacific Petroleums, Ltd. completed expansion of its Taylor refinery to bring capacity to 14,300 b/d. Chevron Standard Limited will complete the $50 million expansion program of its Burnaby plant in 1976, more than doubling current capacity to 45,000 b/d.

Marketing and trade

Crude oil deliveries to Canadian refineries during 1975 averaged 1,702,000 b/d, down 70,000 b/d from 1974. Demand for domestic crude oil by Canadian refiners declined by 74,000 b/d or 8 per cent to 878,000 b/d. Most of this decrease was due to lower use of western Canadian crude oil by Quebec and Maritime refiners. Shipments to those areas were initiated late in 1973 because of a partial embargo on exports of crude oil to Canada by Arab oil-producing states. Western Canada deliveries to the Atlantic region averaged 75,000 b/d in 1974 but declined in 1975 to 6,800 b/d as more foreign oil became available. However, when Interprovincial's Montreal extension comes on stream in 1976, Montreal refiners are expected to take up to 250,000 b/d of western Canadian crude oil initially. Future deliveries above this level will depend upon future supply-demand factors. Remaining shipments of domestic crude oil went to refiners in Ontario and western Canadian refiners.

On the other hand, use of imported crude oil by Canadian refineries in Quebec and the Maritime Provinces increased to 824,000 b/d, 4,000 b/d more than in 1974. Countries in the Middle East collectively remained the largest source of imported crude oil to Canada; imports from the area increased by 23 per cent to 518,000 b/d. Middle East sources of imported oil were Iran, Saudi Arabia, Iraq, Kuwait, and the Trucial

Table 14. Consumption of petroleum products by province, 1975[p]

	Motor Gasoline	Kerosene, Stove Oil, Tractor Fuel	Diesel Fuel Oil	Light Fuel Oils #2 and 3	Heavy Fuel Oils #4, 5 and 6
	(thousands of barrels)				
Newfoundland	3,592,014	1,175,480	2,632,269	3,286,438	4,419,251
Atlantic provinces	15,002,928	2,535,258	5,867,770	12,589,143	22,222,738
Quebec	52,902,066	4,894,777	12,692,482	39,430,523	38,807,090
Ontario	77,671,722	2,273,803	15,985,977	34,914,789	22,104,553
Manitoba	9,282,122	814,355	4,152,580	1,574,734	1,342,928
Saskatchewan	12,721,004	1,505,782	5,482,645	1,426,545	215,755
Alberta	22,929,790	548,060	10,175,862	985,288	1,158,317
British Columbia	22,586,390	1,575,415	10,112,603	6,500,005	8,173,028
Northwest Territories and Yukon	608,136	475,214	1,478,541	763,674	172,686
Total	217,296,172	15,798,174	68,580,729	101,471,139	98,616,346

Source: Statistics Canada.
[p]Preliminary

States. Iran accounted for some 40 per cent of the imports from this area. Imports from Venezuela declined by 26 per cent to 258,000 b/d. This is the second consecutive year that Canada imported substantially less crude oil from Venezuela but that country continues to be Canada's principal single source of crude oil imports. Imports of African oil from Nigeria and Libya increased by 74 per cent to 36,000 b/d in 1975.

Exports to the United States of crude oil and equivalent decreased by 21 per cent to 719,000 b/d in 1975. The decrease was due to the Canadian export control system. Under the terms of this system, exports to the United States were reduced to 800,000 b/d in January 1975 and further reduced to 650,000 b/d July 1, 1975. The latter figure subsequently was raised to 750,000 b/d. United States refiners east of the Rocky Mountains received an average of 539,000 b/d of Canadian crude oil, 150,000 b/d less than last year; those west of the Rockies, in the Puget Sound area, imported about 180,000 b/d of Canadian crude oil, almost 36,000 b/d less than in 1974.

Exports of petroleum products in 1975, including gas plant propane and butane, amounted to 187,000 b/d, about 25,000 b/d less than in 1974, the result of a continuing softening market in the United States' northeastern states. As a result, the large refineries in Quebec and the Maritimes that were constructed, in part, to serve this market have been producing at below rated capacity.

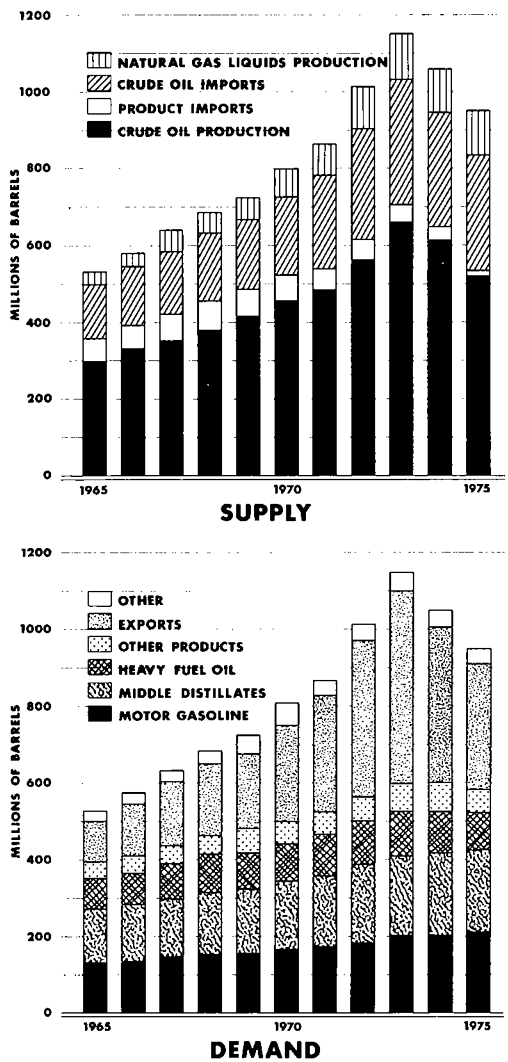
In 1975 imports of petroleum products again declined substantially to 40,000 b/d compared to 83,000 b/d in 1974. With the current surplus of refinery capacity in the eastern provinces, the trend to reduced imports of petroleum products is expected to continue. To summarize, if gas plant production is taken into account, Canada remained a net exporter of crude oil and products as exports exceeded imports by 37,750 b/d. However, analysis of our current supply suggests this circumstance will not likely be maintained much longer.

Imports of crude oil accounted for almost 48 per cent of Canadian refinery requirements in 1975, 2 per cent more than the previous year. Canada's self-sufficiency index (consumption of refined petroleum products versus output of crude oil and equivalent) declined to 92.8 per cent compared to 105 per cent in 1974. The decline was due to restrictions in the flow of exported oil to the United States and the lessening in the demand for refined petroleum products from the export-oriented eastern Canada-based refineries. This imbalance of crude oil trade will be alleviated to some degree when the Montreal extension of the Interprovincial pipeline system is fully operational.

In the realm of government activity, on July 30, 1975, royal assent was given to Bill C-8, the Petro Canada Act, establishing a national petroleum company. Under this Act, the Crown comany (Petro-Canada) will have the authority "to explore for hydrocarbon deposits; to negotiate for and acquire petroleum

PETROLEUM SUPPLY—DEMAND IN CANADA

MINERAL DEVELOPMENT SECTOR
DEPARTMENT OF ENERGY, MINES AND RESOURCES



SOURCE : STATISTICS CANADA

products from abroad to assure a continuity of supply for the needs of Canada, to develop and exploit deposits of hydrocarbons within and without Canada in the interests of Canada; to carry out research and development projects in relation to hydrocarbons and other fuels and to engage in exploration for and the production, distribution, refining and marketing of, fuels".

The national petroleum company will have up to $1.5 billion in federal funding, but only $15 million is budgeted for organizational costs in the fiscal year ending March 31, 1976. The company is also committed to expenditures of $300 million for a 15 per cent working interest in the Syncrude Canada Ltd. Athabasca bituminous sands project. Expenditures will be spread over the Syncrude construction period, which is scheduled to end in 1978.

Late in 1975, and acting on the recommendations of the National Energy Board's latest report dealing with Canada's future oil supplies and requirements, the Canadian government further reduced crude oil exports to the United States in 1976 by 240,000 b/d. This will bring the average level of oil exports to 460,000 b/d in 1976 and by 1981 exports are expected to be phased out completely. The reduction from current production levels of approximately 700,000 b/d will take place in two stages. A maximum of 510,000 b/d will be allowed prior to the start-up of the Sarnia-Montreal pipeline now under construction. Exports will be reduced further as the pipeline begins operation and authorized exports will be 385,000 b/d when the pipeline reaches its projected throughput rate of 250,000 b/d. The reason for the cutbacks is the Board's recent downward revision of its estimates of producibility from the established producing areas in the early years of its 20-year forecast period, and a slower rate of oil sands development in the later years. The Board's latest assessment of supply and demand trends shows, that by 1982, there will not be enough crude oil produced in Canada to serve traditional Canadian markets (the area west of the Ottawa Valley) and to supply the Montreal refining area with an additional 250,000 b/d.

Table 15. Canada, exports and imports of refined petroleum products, 1974-75

	Exports		Imports	
	1974	1975ᵖ	1974	1975ᵖ
	(millions of barrels)			
Propane and butane	37.29	36.42	0.07	0.06
Aviation gasoline	—	—	0.03	0.02
Motor gasoline	1.00	4.87	0.03	0.19
Aviation turbo fuel	1.21	0.65	1.84	0.58
Kerosene, stove oil and tractor fuel	0.07	0.05	0.18	0.27
Diesel fuel oil	0.70	1.15	1.34	0.71
Light fuel oil #2 and 3	2.44	3.93	1.89	1.38
Heavy fuel oil #4, 5 and 6	28.64	19.52	18.74	7.24
Asphalt	0.19	0.31	0.06	0.08
Petroleum coke	0.04	0.02	3.89	1.74
Lubricating oils	—	0.01	1.64	1.32
Other products	5.65	1.30	0.57	0.99
Total, all products	77.23	68.23	30.28	14.73

Sources: Statistics Canada and National Energy Board.
ᵖPreliminary; — Nil.

Table 16. Canada, supply and demand of oils, 1974-1975

	1974ʳ	1975ᵖ
	('000 barrels)	
Supply		
Production		
Crude oil and condensates	614,777	520,818
Other natural gas liquids	113,304	112,179
Net production	728,081	632,997
Imports		
Crude oil	299,239	301,928
Products	30,275	14,769
Total imports	329,514	316,697
Change in stocks		
Crude and natural gas liquids	−967	−7,397
Refined petroleum products	−13,663	+4,446
Total change	−14,630	−2,951
Oils not accounted for	+992	+3,345
Total supply	1,043,957	950,088
Demand		
Exports		
Crude oil	330,583	262,455
Products	73,319	68,003
Total exports	403,902	330,458
Domestic sales		
Motor gasoline	207,280	216,530
Middle distillates	211,031	207,677
Heavy fuel oil	110,142	97,384
Other products	71,292	58,914
Total sales	599,745	580,505
Uses and losses		
Refining	43,102	41,756
Field plant and pipeline	3,159	2,079
Losses and adjustments[1]	−5,951	−4,710
Total uses, losses and adjustments	40,310	39,125
Total demand	1,043,957	950,088

Source: [1] Statistics Canada and provincial government reports.
ᵖPreliminary; ʳRevised.

Failing to reach a federal-provincial agreement on prices in April, the federal government in June raised the average price of crude oil and equivalent by $1.50 a barrel to $8.00 a barrel, effective July 1, 1975. The provincial and federal governments had agreed in January, 1974 on a price of $6.50 a barrel, but this agreement expired on June 30, 1975. The 1975 increase is equivalent to about five cents a gallon in the wholesale price across the range of petroleum products. The agreement between the federal government and producing provinces regarding domestic price levels for oil and natural gas extends to the end of June 1976. It will be reviewed prior to this date and it is likely that crude oil prices will be increased again as the majority of the governments involved have expressed a commitment to see Canadian oil prices increased towards current international prices.

Phosphate

B.W. BOYD

During 1975, world prices of phosphate rock reached a peak which was five times the price in 1973 and which had far-reaching effects on the world fertilizer industry. The quantity of phosphate rock imported into Canada decreased marginally from 1974, while the value more than doubled. About four-fifths of the world's phosphate consumption is for agriculture, largely fertilizers. The increased cost of rock led to increased fertilizer prices in Canada and the rest of the world and, consequently, sales and production of phosphate products decreased from 1974 levels.

Phosphate rock

Phosphate is a term applied to a rock, mineral, or salt containing one or more phosphorous compounds. Phosphate rock contains one or more suitable phosphate minerals, usually calcium phosphate, in sufficient quantity for use, either directly or after beneficiation, in the manufacture of phosphate products. Sedimentary phosphate rock, or phosphorite, is the most widely used phosphate raw material; apatite, which occurs in many igneous and metamorphic rocks, and can be represented by the formula $Ca_5(PO_4)_3$ (F, Cl, OH), is second in importance. Other sources of phosphate include guano and a basic slag byproduct of some steel mills. Phosphate rock can be decomposed by three methods; acid treatment, thermal reduction, or thermal treatment without reduction. Canadian phosphate producers use the first two methods.

Phosphate rock is graded either on the basis of its P_2O_5 equivalent (phosphorus pentoxide) or $Ca_3P_2O_5$ content (tricalcium phosphate or bone phosphate of lime — TPL or BPL). For comparative purposes, 0.458 P_2O_5 equals 1.0 BPL, and one unit of P_2O_5 contains 43.6 per cent phosphorus.

Occurrences in Canada

Although there are numerous occurrences of low-grade phosphate rock in Canada, there is no commercial production in this country. Large quantities of rock are imported, mostly from the United States, for use in the manufacture of agricultural and industrial products sold in domestic and export markets.

Known Canadian deposits are limited and fall into three main categories: apatite deposits within Precambrian metamorphic rocks in eastern Ontario and southwestern Quebec; apatite deposits in some carbonate-alkaline complexes (carbonatites) in Ontario and Quebec; and Late Paleozoic-Early Mesozoic sedimentary phosphate rock deposits in the southern Rocky Mountains.

The Precambrian metamorphic apatite deposits of Ontario and Quebec occur in pyroxenites as small, irregular, scattered pockets and veins with phlogopite mica and pink calcite. Most of the outcrops are in the Rideau Lakes region of eastern Ontario and the Lièvre River area of southwestern Quebec where many deposits were worked extensively between 1869 and 1900, before low-cost Florida rock entered world markets.

Carbonatites usually occur as roughly circular plugs intruding older metamorphic rock. In August 1975, International Minerals & Chemical Corporation (Canada) Limited (IMCC) reported a phosphate deposit in a carbonatite complex in Cargill Township, Ontario. Part of the complex was described in 1967 by the Ontario Department of Mines as being cut by very coarse white calcite veins containing up to 20 per cent apatite. By the end of 1975 IMCC had drilled 192 holes, of which 150 were on the main deposit and the remainder were for reconnaissance on and around the carbonatite plug. Other important apatite-bearing carbonatites are the Nemegos deposit, 15 miles southeast of Chapleau, Ontario, held by Multi-Minerals Limited; and the Oka deposit 20 miles west of Montreal, currently being mined for columbium (niobium) by St. Lawrence Columbium and Metals Corporation.

Sedimentary phosphate beds are fairly common in the Rocky Mountains. Most of the exposures occur along the Alberta-British Columbia border between the International Boundary and Banff. Beds at the base of the Fernie shale have received considerable attention during recent years.

Canadian phosphate industry

Elemental phosphorus. Elemental phosphorus is produced in Canada by the thermal reduction method,

Table 1. Canada, phosphate rock imports and consumption, 1974-75

	1974		1975p	
	(short tons)	($)	(short tons)	($)
Imports				
United States	3,685,183	39,788,000	3,607,963	84,610,000
South Africa	—	—	7,466	334,000
Netherlands Antilles	3,982	280,000	2,640	226,000
Total	3,689,165	40,068,000	3,618,069	85,170,000
	1973		1974p	
Consumption[1] (Available data)				
Fertilizer, stock and poultry feed	2,166,332		2,320,670	
Other[2]	264,032		212,865	
Total	2,430,364		2,533,535	

Source: Statistics Canada.
[1]Breakdown by Mineral Development Sector, Department of Energy, Mines and Resources, Ottawa. [2]Includes amounts for chemicals, refractories, food processing, medicinals and pharmaceuticals.
pPreliminary; — Nil.

which involves the smelting of phosphate rock with carbon (coke) and a siliceous flux. Co-products of the process are ferrophosphorus, carbon monoxide and calcium silicate slag. About nine tons of phosphate rock grading 66-68 per cent BPL are required to manufacture one ton of phosphorus. Although elemental phosphorus can be used for making fertilizers, it is generally used in the manufacture of chemicals, insecticides, detergents and other industrial compounds. There are two plants producing elemental phosphorus in Canada.

Phosphate fertilizers. Phosphate fertilizers are normally produced by decomposing phosphate rock with a strong mineral acid. In Canada, only the two most common acidulents, sulphuric acid and phosphoric acid, are used in commercial practice; the former is by far the most common.

When phosphate rock is treated with sulphuric acid, either single superphosphate or phosphoric acid (correctly named orthophosphoric acid, H_3PO_4) is produced. For the former, the rock is treated with sufficient acid to convert the tricalcium phosphate into water-soluble monocalcium phosphate; the coproduct of the reaction, calcium sulphate, remains in the mixture. Normal raw material requirements to produce one ton of superphosphate, grading 20 per cent P_2O_5 equivalent, are 0.64 ton of phosphate rock (70-72 per cent BPL) and 0.47 ton of sulphuric acid (100 per cent basis).

To produce phosphoric acid, larger quantities of sulphuric acid are added to maintain a fluid slurry that facilitates removal of calcium sulphate by filtering. Filtered acid, containing 30 to 32 per cent P_2O_5 equivalent may be used either directly in the manufacture of phosphate fertilizers or concentrated by evaporation to as high as 54 per cent P_2O_5 equivalent prior to further use or sale as merchant acid. Typical raw material requirements for one ton P_2O_5 equivalent produced are 3.1 tons of phosphate rock (74-75 per cent BPL) and 2.6 tons of sulphuric acid (100 per cent basis). Also, for every ton P_2O_5 equivalent produced, about 4.5 tons of waste calcium sulphate are generated.

Most of the acid is then neutralized with ammonia to form ammonium phosphate fertilizers. Common grades are 16-20-0 (16 per cent N, 20 per cent P_2O_5 equivalent, and 0 per cent K_2O equivalent), 11-48-0 and 18-46-0. At some plants, phosphoric acid is used to

Table 2. Canada, phosphate rock imports and consumption, 1966-75

	Imports	Consumption
	(short tons)	
1966	2,181,341	1,735,488
1967	2,279,767	2,275,095
1968	2,349,980	2,234,259
1969	2,201,331	1,822,069
1970	2,470,050	1,896,684
1971	2,844,453	2,031,289
1972	2,985,102	2,362,010
1973	3,678,617	2,430,364
1974	3,689,165	2,533,535
1975p	3,618,069	. .

Source: Statistics Canada.
pPreliminary; . . Not available.

Table 3. World production of phosphate rock, 1973-75

	1973	1974	1975
	(000 short tons)		
United States	42,137	45,685	49,090
U.S.S.R.	23,237	24,807	26,588
Morocco	18,259	21,303	14,934
Tunisia	3,814	4,302	3,837
People's Republic of China	3,031	3,307	3,748
Sahara	767	2,630	2,956
Senegal	1,931	2,070	1,849
South Africa	1,491	1,571	1,820
Nauru	2,561	2,522	1,691
North Vietnam	441	1,268	1,543
Jordan	1,197	1,764	1,491
Christmas Island	1,646	1,994	1,480
Togo	2,504	2,814	1,280
Algeria	670	884	737
Israel	827	1,102	672
Arab Republic of Egypt	595	606	661
Other countries	2,357	3,037	2,568
Total	107,465	121,666	116,945

Source: The British Sulphur Corporation Ltd., Statistical Supplement May/June 1976.

acidulate phosphate rock, in which case the end product is triple superphosphate, normally grading 46 per cent P_2O_5 equivalent.

There are 10 phosphoric acid plants in Canada with a combined annual productive capacity of 1,161,000 tons P_2O_5 equivalent. The balance of Canada's P_2O_5 productive capacity, amounting to 21,000 tons annually, consists of plants that are capable of producing single and/or triple superphosphate.

Prices. The price of phosphate rock from Florida and Morocco was high throughout 1975 although world demand fell by 10,000,000 tons and stockpiles grew in most exporting countries. In May 1975 the Office Cherifien des Phosphates (OCP) of Morocco announced that the rock prices would not be changed before June 1976. This action dispelled the rumors of price reductions which had led some consumers to postpone orders. However, prices paid for phosphate rock from Morocco did fall toward the end of 1975 and the new prices posted for January 1976 were significantly lower than the last official prices announced in January 1975.

The world prices for fertilizer products decreased during the year as producers responded to a fall in fertilizer demand brought about by stockpiling in 1974. Diammonium phosphate (DAP) sold for $380 – $400 per ton in January but by November some sales were made at prices as low as $155 per ton. Prices are expected to recover somewhat in 1976.

Production, trade and consumption. Nearly all Canada's trade in phosphate fertilizers is with the United States, mostly in areas where plants are close to farming communities. Under foreign aid programs, shipments are occasionally made to southeast Asian countries. Preliminary figures indicate that imports of phosphate rock in 1975, at 3,618,069 tons, were 71,000 tons lower than in 1974, and phosphate fertilizer production decreased by 39,000 tons to 728,527 tons P_2O_5 equivalent, the lowest level in four years.

Imports of phosphate fertilizer increased by 48,000 tons P_2O_5 equivalent to 81,353 tons, the highest level since 1964. Fertilizer imported from the United States entered the domestic market usually served by Canadian producers when the cost of imported phosphate rock increased in 1974 and 1975 and forced up the selling price of Canadian fertilizer product. Many United States fertilizer producers have captive phosphate rock mines and because they were insulated from the dramatic increases in the price of rock they could undersell the Canadian producers. In the export market also Canadian product was supplanted by United States fertilizer. Consequently, exports fell by nearly 74,000 tons to 199,034 tons P_2O_5 equivalent.

Outlook. Despite a continuing world food shortage, fertilizer sales have been affected by the world-wide decline in industrial activity and inflationary factors associated with the universal energy crisis. Fertilizer plants in Canada operated below capacity throughout the year but inventories increased. The outlook is for increased sales in 1976, as the price of phosphate rock falls and Canadian producers are better able to compete in the North American market.

Table 4. Canada, phosphate fertilizer production, years ended June 30, 1966-75

	short tons P_2O_5 equivalent
1966	461,608
1967	533,460
1968	538,796
1969	523,934
1970	496,380
1971	619,669
1972	745,667
1973	813,972
1974	767,566
1975[p]	728,527

Source: Statistics Canada.
[p]Preliminary.

Table 5. Canada, phosphorus and phosphate fertilizer plants, 1975

Company	Plant Location	Annual Capacity	Principal End Products	Basis for H_2SO_4 Supply for Fertilizer Plants
		(short tons)		
Elemental phosphorus				
Erco Industries Limited[1]	Varennes, Que.	20,000	el ph	
	Long Harbour, Nfld.	80,000	el ph	
Total elemental phosphorus		100,000		
Phosphate fertilizer		(P_2O_5 eq.)		
Canada Wire and Cable Limited[2]	Belledune, N.B.	125,000	am ph	SO_2 smelter gas
Canadian Industries Limited	Beloeil, Que.	20,000	ss	sulphur
	Courtright, Ont.	93,000	am ph	SO_2 pyrrhotite, Copper Cliff
Cominco Ltd.	Kimberley, B.C.	129,000	am ph	SO_2 smelter gas
	Trail, B.C.	84,000	am ph	SO_2 smelter gas
International Minerals & Chemical Corporation (Canada) Limited	Port Maitland, Ont.[3]	208,000	H_3PO_4, ss ts, ca ph	sulphur, SO_2 smelter gas
Green Valley Fertilizer & Chemical Co. Ltd.	North Surrey, B.C.	1,000	ss	SO_2 smelter gas Trail
Imperial Oil Limited	Redwater, Alta.	210,000	am ph	sulphur
Northwest Nitro-Chemicals Ltd.	Medicine Hat, Alta.	70,000	am ph	sulphur
St. Lawrence Fertilizers Ltd.	Valleyfield, Que.	56,000	ts, am ph	SO_2 smelter gas
Sherritt Gordon Mines Limited	Fort Saskatchewan, Alta.	65,000	am ph	sulphur
Simplot Chemical Company Ltd.	Brandon, Man.	. .	am ph	imports H_3PO_4
Western Co-operative Fertilizers Limited	Calgary, Alta.	120,000	am ph	sulphur
Total, phosphate fertilizer		1,181,000		

el ph Elemental phosphorus; P_2O_5 eq. Phosphorus pentoxide equivalent; am ph Ammonium phosphates; ss Single superphosphate; Triple superphosphate; ca ph Food supplement calcium phosphate; . . Not applicable, H_3PO_4 is made elsewhere.
[1]Electric Reduction Company of Canada, Ltd. changed its name to Erco Industires Limited, effective January 1, 1973. [2]Noranda Mines Limited acquired full ownership of Belledune Fertilizer Limited, effective April 1, 1972, name changed to Canada Wire and Cable Limited, June 5, 1972. [3]Operates at less than annual capacity because of environmental restrictions.

Table 6. Canada, trade in selected phosphate products, 1974-75

	1974		1975^p	
	(short tons)	($)	(short tons)	($)
Imports				
Calcium phosphate				
United States	19,598	3,197,000	14,012	3,318,000
United Kingdom	—	—	11	4,000
Other countries	81	25,000	1	. .
Total	19,679	3,222,000	14,024	3,322,000
Fertilizers				
Normal superphosphate, 22% P_2O_5 or less				
United States	11,999	566,000	3,194	194,000
Triple superphosphate over 22% P_2O_5				
United States	23,140	1,856,000	47,207	6,581,000
Phosphate fertilizers, nes				
United States	65,257	9,541,000	89,911	14,981,000
Belgium-Luxembourg	1,507	481,000	593	246,000
United Kingdom	319	141,000	201	115,000
Netherlands	59	30,000	40	19,000
France	241	30,000	—	—
Sweden	20	9,000	—	—
West Germany	2	4,000	—	—
Total	67,405	10,236,000	90,745	15,361,000
Chemicals				
Potassium phosphates				
United States	3,801	1,435,000	3,190	1,591,000
Sodium phosphate tribasic				
United States	3,119	543,000	2,144	563,000
France	18	7,000	—	—
Total	3,137	550,000	2,144	563,000
Sodium phosphate nes				
United States	4,009	1,336,000	5,210	2,320,000
West Germany	98	37,000	128	69,000
United Kingdom	1	2,000	4	9,000
Total	4,108	1,375,000	5,342	2,398,000
Exports				
Nitrogen-phosphate fertilizers, nes				
United States	460,159	51,011,000	411,584	67,063,000
Pakistan	—	—	30,774	8,043,000
Belgium-Luxembourg	42,623	2,367,000	44,414	7,776,000
Ireland	36,619	3,393,000	6,068	1,026,000
Japan	11,417	1,320,000	1,927	313,000
Indonesia	16,764	5,404,000	—	—
Chile	28,749	3,211,000	—	—
Other countries	42,882	3,558,000	—	—
Total	639,213	70,264,000	494,767	84,221,000

Source: Statistics Canada.
^{p} Preliminary; nes Not elsewhere specified; — Nil; . . Less than one thousand dollars.

Table 7. Canada, phosphate fertilizer consumption and trade, years ended June 30, 1966-75

	Consumption	Imports[1]	Exports
	(short tons P_2O_5 equivalent)		
1966	367,591	65,498	126,524
1967	412,214	73,936	138,133
1968	440,093	43,726	165,048
1969	347,813	24,054	161,051
1970	309,400	11,293	218,501
1971	359,781	11,421	338,779
1972	375,682	43,906[r]	300,705
1973	457,784	52,301[r]	331,522
1974	544,795	33,174	272,932
1975[p]	553,016	81,353	199,034

Source: Statistics Canada.
[1]Excludes nutrient content of mixtures and of orthosphoric acid.
[p]Preliminary; [r]Revised.

Table 8. Listed export prices for Florida phosphate rock

Grade	January 1974	July 1974	October 1974	January 1976
	(U.S. $ per short ton fob Tampa or Jacksonville)			
77/76% TPL	26.79	42.41	56.25	. .
75/74% TPL	24.56	37.50	49.90	42.64
72/70% TPL	21.43	32.14	43.54	37.19
70/68% TPL	19.64	29.47	39.01	33.57
68/66% TPL	17.85	26.79	35.38	29.94
66/64% TPL	16.08	24.56	32.66	27.22

Source: British Sulphur Corporation Limited. Conversion to short ton prices by Mineral Development Sector, Department of Energy, Mines and Resources, Ottawa.
. . Not available.

Table 9. Listed export prices for Moroccan phosphate rock

Grade	January 1974	July 1974	January 1975	January 1976
	(U.S. $ per short ton fas Casablanca, Safi or El Aaiun)			
Bu Craa				
80/82% TPL	–	–	–	50.0
Khouribga				
77/79% TPL (calcined)	42.86	64.41	69.40	46.72
75/77% TPL	38.10	57.15	61.69	44.00
70/72% TPL	36.29	54.43	58.97	41.73
Youssoufia				
70/72% TPL	34.02	51.03	55.11	39.01

Source: British Sulphur Corporation Limited. Conversion to short ton prices by Mineral Development Sector.

Platinum Metals

J. J. HOGAN

The platinum group metals consist of platinum, palladium, rhodium, iridium, ruthenium and osmium. The metals are found in nature associated with basic and ultrabasic rocks and in placer deposits, although production from placers is now of minor importance. A large quantity of platinum metals comes from mines worked principally for those metals, mainly in the Republic of South Africa; a substantial amount is also recovered as a byproduct from the treatment of nickel-copper ores.

The major producers, ranked in decreasing order of production volume, are the Republic of South Africa, the U.S.S.R. and Canada. Minor producers are Colombia, the United States, Japan and the Philippines.

Canadian production of platinum group metals in 1975 was estimated at 430,000 ounces* valued at $61,231,000 compared with 384,618 ounces in 1974 valued at $60,794,030. Although volume increased by 11.8 per cent the dollar value was up only slightly because of a substantial decrease in the producer price of most platinum metals, especially platinum and palladium. These account for the largest quantity of platinum group metals recovered in Canada. Platinum metals output in Canada is derived as a byproduct of nickel-copper refining operations in the Sudbury district of Ontario and the Thompson district of Manitoba.

World primary production of the platinum group metals in 1975 was estimated at 5,781,000 ounces compared with 5,772,618 ounces in 1974. The two largest South African producers initiated a 25 per cent reduction in output early in 1975 in order to bring about a better balance between supply and demand. Despite the cut-back in production, South Africa was the leading world producer of platinum metals in 1975, followed closely by the U.S.S.R. These two countries were responsible for 91.7 per cent of world output in 1975 and Canada, the third largest producer, accounted for 7.4 per cent.

Japan and the United States were the leading consumers of platinum group metals in the noncommunist world in 1975 with Japan being the largest, mainly because of a continuing strong domestic demand for platinum jewellery. Japan accounted for about 42 per cent of the total noncommunist world consumption in 1975, the United States for 31 per cent and other countries 27 per cent. Japan's consumption of platinum in 1975 was estimated at about 1.4 million ounces, of which approximately 80 per cent was used in the fabrication of jewellery.

The United States Bureau of Mines (USBM) estimated the platinum group metals sold to industry in the United States in 1975 at 1,310,037 ounces. The percentages of platinum group metals sold to the U.S. consuming industries were: platinum, 53.3; palladium, 41.4; rhodium, 2.8; ruthenium, 1.7; iridium, 0.7 and osmium, 0.1. The major consumers in the U.S. were the automotive, chemical and electrical industries which together accounted for 70 per cent of the total. Preliminary estimates show that consumption of platinum and palladium (73.8 and 26.2 per cent, respectively) in the U.S. automotive industry in 1975 was 370,000 ounces. The USBM reports the stocks of platinum group metals held by refiners, importers and dealers in the United States at the end of 1975 at 849,210 ounces, substantially below the 1,137,377 ounces at the end of 1974.

Canadian operations and developments

The platinum group metals produced in Canada were recovered as a byproduct from the treatment of the nickel-copper sulphide ores, principally those in the Sudbury district of Ontario and the Thompson-Wabowden region of Manitoba. In processing these ores for recovery of nickel and copper, the platinum metals concentrate in the sludge formed during the electrolytic refining of the nickel-copper anodes. The sludge produced by The International Nickel Company of Canada Limited (Inco) is shipped to its refinery at Acton, England for the extraction and refining of the platinum metals. Falconbridge Nickel Mines Limited ships nickel-copper matte from its Falconbridge, Ontario plant to its refinery in Kristiansand, Norway. The sludge collected from this operation is shipped to Engelhard Minerals & Chemicals Corporation at Newark, New Jersey for recovery of the contained platinum metals. In Canada, the metal ratios of the platinum group metals

*The term "ounce" refers to the troy ounce throughout unless otherwise specified.

Table 1. Canada, platinum metals, production and trade, 1974-75

	1974		1975p	
	(troy ounces)	($)	(troy ounces)	($)
Production[1]				
Platinum, palladium, rhodium, ruthenium, iridium	384,618	60,794,030	430,000	61,231,000
Exports				
Platinum metals in ores and concentrates				
United Kingdom	487,289	53,904,000	429,867	43,009,000
Norway	36,820	4,738,000	3,242	434,000
United States	614	87,000	—	
Total	524,723	58,729,000	433,109	43,443,000
Platinum metals, refined				
United Kingdom	4,638	467,000	45,586	4,350,000
United States	21,469	2,985,000	17,792	2,074,000
West Germany	—	—	2,724	355,000
Other Countries	247	52,000	120	22,000
Total	26,354	3,504,000	66,222	6,801,000
Platinum metals in scrap				
United States	27,846	4,279,000	17,248	2,681,000
United Kingdom	3,026	522,000	3,168	385,000
West Germany	—	—	987	79,000
Total	30,872	4,801,000	21,403	3,145,000
Re-export[2]				
Platinum metals, refined and semiprocessed	37,873	3,680,000	17,326	2,928,000
Imports				
Platinum lumps, ingots, powder and sponge				
United States	97	26,000	4,409	743,000
United Kingdom	1,914	311,000	785	135,000
Panama	—	—	20	2,000
Total	2,011	337,000	5,214	880,000
Other platinum group metals				
United States	25,048	3,567,000	44,484	3,793,000
United Kingdom	16,380	2,454,000	5,673	944,000
South Africa	5,685	489,000	5,600	444,000
Total	47,113	6,510,000	55,757	5,181,000
Total platinum and platinum group metals				
United States	25,145	3,593,000	48,893	4,536,000
United Kingdom	18,294	2,765,000	6,458	1,079,000
South Africa	5,685	489,000	5,600	444,000
Panama	—	—	20	2,000
Total	49,124	6,847,000	60,971	6,061,000

Table 1. (concl'd)

	1974		1975	
	(troy ounces)	($)	(troy ounces)	($)
Platinum crucibles[3]				
United States	18,750	3,480,000	17,062	3,836,000
Switzerland	—	—	2	. . .
United Kingdom	—	—	1	. . .
Total	18,750	3,480,000	17,065	3,837,000
Platinum metals, fabricated materials, not elsewhere specified				
United Kingdom	30,119	4,744	26,805	4,522,000
United States	26,877	1,576	10,689	913,000
Total	56,996	6,320	37,494	5,435,000

Source: Statistics Canada.
[1]Platinum metal, content of concentrates, residues and matte shipped for export. [2]Platinum metals, refined and semiprocessed, imported and re-exported after undergoing no change or alteration. [3]Includes spinnerets and bushings.
[p] Preliminary; — Nil; . . . Less than one thousand dollars.

are approximately 46 per cent platinum, 40 per cent palladium and 14 per cent other platinum metals.

Inco, the largest producer of platinum group metals in Canada, operated 12 nickel-copper mines, four concentrators, a nickel-copper smelter and a nickel pellet and powder refinery in the Sudbury area, Ontario. Elsewhere in Ontario, Inco operated a nickel refinery at Port Colborne and a mine-concentrator complex at Shebandowan near Thunder Bay. Falconbridge Nickel operated eight nickel-copper mines, three concentrators and one smelter in the Sudbury district.

In November 1975 three nickel-copper mines and a concentrator were closed and placed on a stand-by basis because of the greatly-reduced demand for nickel in world markets. In the Timmins area, the Langmuir mine, owned 51 per cent by Noranda Mines Limited, and 49 per cent by Inco, shipped its concentrate to the Inco smelter at Copper Cliff. Kanichee Mining Incorporated, near Temagami, shipped its concentrate to Falconbridge's smelter at Falconbridge, Ontario. At the end of 1975 Falconbridge notified Kanichee it would terminate its agreement to purchase Kanichee's concentrates, but would accept shipments until February 1976.

Three companies in Manitoba recover platinum metals from nickel-copper sulphide ores. Inco operated three mines and a concentrator-smelter-refinery complex in the Thompson region. At Wabowden, Falconbridge Nickel operated a mine and concentrator and shipped the concentrates to its smelter in Ontario. Ore from Dumbarton Mines Limited, in the Bird River area, was custom-treated at the Werner Lake concentrator of Consolidated Canadian Faraday Limited in Ontario. The nickel-copper concentrate produced was shipped to the Falconbridge smelter at Falconbridge. The hydrometallurgical process used by Sherritt Gordon Mines Limited to recover nickel from its Lynn Lake mine does not lend itself to the economic recovery of platinum metals.

A platinum metals discovery was made in 1974 by Sheridan Geophysics Limited in the Lac des Isles area, about 55 miles north of Thunder Bay, Ontario. The initial exploration on this property was carried out by Boston Bay Mines Limited. In May 1975, Texasgulf Inc. optioned the property. According to press reports, the agreement calls for Texasgulf to carry out an exploration program on the property over an 18-month period. Should the company decide to exercise its option at the end of this period, an initial payment of $5 million would be made to Boston Bay. Further payments amounting to $20 million dollars would be made over the first ten years of production. Drilling by Texasgulf has indicated a mineralized zone about 3,000 feet long and 500 feet deep containing platinum metals with minor amounts of nickel and copper. The zone is open at both ends and at depth. The width of the zone and the platinum metals content vary considerably, the width averaging over 100 feet and the grade ranging from 0.10 to over 0.20 ounces of platinum metals a ton. Preliminary work indicated the ratio of palladium to platinum is about 8 to 1.

Foreign developments

Republic of South Africa: The major platinum group metals producers in the Republic of South Africa, the noncommunist world's largest supplier of platinum metals, announced in February 1975 a cutback in output of about 25 per cent to bring supply in line with demand. Platinum metals operations were adversely affected by the depressed world price for most of the platinum metals in 1975 and an escalation of over 25 per cent in the cost of production. A substantial part of the increased production costs was directly attributable to increases in wages paid to African and European

Table 2. Canada, platinum metals, production and trade, 1966-75

	Production[1]		Exports Domestic[2]		Exports Re-export[3]		Imports[4]	
	(ounces)	($)	(ounces)	($)	(ounces)	($)	(ounces)	($)
1966	396,059	32,370,064	441,625	25,800,000	199,152	11,779,822	197,853	14,930,000
1967	401,263	34,668,915	475,855	29,829,000	164,033	9,087,955	212,889	13,161,000
1968	485,891	46,199,718	584,942	38,068,000	83,228	8,254,753	207,961	17,077,000
1969	310,404	30,881,016	463,500	35,306,000	52,694	5,247,240	118,946	9,300,000
1970	482,428	43,556,597	650,066	43,174,000	20,399	2,365,735	60,745	3,123,000
1971	475,169	39,821,616	224,796	23,917,000	35,523	3,185,000	53,608	3,298,000
1972	406,048	34,656,545	429,622r	33,370,000r	33,376	4,542,000	47,719	2,858,000
1973	354,223	41,993,743	460,597r	34,579,000r	49,762	5,248,000	63,952	5,655,000
1974	384,618	60,794,030	551,077	62,233,000	37,873	3,680,000	49,124	6,847,000
1975p	430,000	61,231,000	499,331	50,244,000	17,326	2,928,000	60,971	6,061,000

Source: Statistics Canada.
[1]Platinum metals, content of concentrates, residues and matte shipped for export. [2]Platinum metals in ores and concentrates and platinum metals, refined. [3]Platinum metals, refined and semi-processed, imported and re-exported after undergoing no change or alteration. [4]Imports, mainly from United States and Britain, of refined and semi-processed platinum metals, derived from Canadian concentrates and residues, a large part of which is re-exported.
p Preliminary; r Revised.

workers. To offset rising labour costs, intensified efforts have been made to improve productivity by increased mechanization in development and mining operations, by training African labour to handle mechanized equipment, and by modifications of mining procedure. The effect of the increased operating costs was partially offset by a 17.9 per cent devaluation of the Rand in October, 1975.

The Republic of South Africa is the only country that mines platinum-bearing ores primarily for the recovery of platinum metals. The deposits, which occur in the Merensky Reef horizon near Rustenberg, also contain some gold, copper and nickel. Platinum group metals recovered from the ores contain approximately 61 per cent platinum, 25 per cent palladium and 14 per cent other platinum group metals. Small amounts of osmium and iridium were recovered as byproducts from the treatment of gold ores.

Rustenberg Platinum Mines Limited, the largest platinum metals producer in the noncommunist world, operated three mines, a smelter and two refineries in the Transvaal district of South Africa, and two refineries in the United Kingdom. Two mines are located in the Union district and one in the Rustenberg district of the Transvaal. The refining of the mine output is carried out in South Africa and the United Kingdom by Matthey Rustenberg Refineries (Proprietary) Limited which was incorporated on March 13, 1972 and is jointly owned by Rustenberg and Johnson, Matthey & Co., Limited.

On February 4, 1975 Rustenberg announced a cutback in its production from an annual rate of about 1.4 million ounces to 900,000 ounces because of a significant drop in sales in January, 1975 and a sharp drop in the forward demand for platinum metals resulting from the cancellation of large orders by contractual customers. The expansion program to increase the over-all mine output to 1.63 million ounces of platinum metals a year will be maintained, but because of continuing adverse market conditions the completion date has been deferred from 1976 to the latter half of 1978. The company reported that expansion of the treatment facilities of Matthey Rustenberg Refineries in the Transvaal was proceeding satisfactorily.

Impala Platinum Limited operated a mine-concentrator-smelter-refinery complex near Rustenberg. Following the lead established by Rustenberg, Impala reduced its annual rated capacity from 950,000 to 600,000 ounces of platinum metals in February 1975.

Western Platinum Limited, jointly owned by Lonrho Limited, Falconbridge Nickel Mines Limited and Superior Oil Company, operated a mine-concentrator-smelter complex with an annual rated capacity of 150,000 ounces of platinum metals in the Transvaal district of South Africa. The company's nickel-copper matte is shipped to Falconbridge's plant in Norway for refining of nickel and copper. Platinum and palladium are recovered at the Lonrho precious metals refinery at Brackpan in the Transvaal. In 1975 an agreement was concluded with the Lonrho refinery for the refining of rhodium, ruthenium and iridium from precious metal sludge. The bulk of the platinum and palladium output from Western Platinum is under contract until the end of 1978, therefore production cutbacks were not necessary. Platinum group metals production from Western Platinum for the fiscal year ending September 30, 1975 was 128,000 ounces, or about 8 per cent less than in 1974.

In May 1975, Atok Platinum Mines (Proprietary) Limited, near Pieterburg, Transvaal completed its program to increase production of platinum metals from 15,000 to 40,000 ounces a year.

Research being carried out in South Africa on the refining of platinum metals has resulted in the development of two new processes. Western Platinum will build an addition to its Brackpan refinery and use a new process developed by the National Institute for Metallurgy (NIM). The NIM process uses solvent-extraction and ion-exchange technology, and all platinum metals and gold can be recovered by this process. The present refinery does not recover rhodium, ruthenium, iridium and osmium. The residues containing these metals are now being stockpiled for recovery at a later date. Anglo Transvaal Consolidated Investments Co. Ltd. (Anglovaal) has developed a batch process for the recovery of all the precious metals. It is claimed that both processes reduce capital outlay for plant construction, yield products of high quality and reduce the retention time of the platinum metals in the circuits.

U.S.S.R.: In the U.S.S.R., platinum metals are derived mainly as a byproduct in the processing of nickel-copper ores in the Norilsk region, northwestern Siberia and the Kola Peninsula of northwest Russia. Small amounts of platinum are recovered from placer deposits in the southern Urals. The United States Bureau of Mines (USBM) estimated the U.S.S.R. production of platinum metals at 2.6 million ounces for the year 1975, compared with 2.5 million ounces in 1974. The U.S.S.R. was carrying out a major expansion program in the Norilsk region to substantially increase nickel output. The first phase of this program, the preparation of a new mine to feed a new smelter complex, was expected to be completed in 1975. The second phase, which involves bringing a second mine into production was slated for completion by 1980. This expansion program should contribute substantially to the quantity of platinum metals produced in the U.S.S.R., especially palladium. The division of the platinum metals in U.S.S.R. ores is about 60 per cent palladium, 30 per cent platinum and 10 per cent other platinum metals.

United States: Mine production of platinum metals in the United States was derived from a placer deposit in the Goodnews Bay area of Alaska and as a byproduct of gold and copper refining. The United States also recovered a substantial quantity of platinum metals from secondary sources. The USBM estimated new and secondary platinum metals recovered in 1975 by refiners in the United States at 316,000 ounces. Mine production was estimated at 16,000 ounces, compared with 13,000 ounces in 1974.

Platinum group metals are found in the rocks of the Stillwater Complex, Sweetgrass County, southwestern Montana. Johns-Manville Corporation carried out an underground drifting and diamond drill program on its property in this district. Significant values in platinum metals have been encountered, as well as smaller amounts of copper-nickel sulphides, silver and gold.

Colombia: Production of platinum metals in Colombia was estimated at 15,000 ounces in 1975, compared with 21,000 ounces in 1974. The platinum metals are recovered as a co-product with gold from placer operations in the Chaco and Narimo districts of Colombia.

Uses

The main applications for the platinum group metals are the chemical, petroleum refining, automotive, electrical and jewellery industries. The industrial uses of platinum-group metals are based on special properties; the principal ones being catalytic activity, resistance to corrosion and to oxidation at elevated temperatures, good electrical properties, high melting point, high strength, good ductility and aesthetic qualities. Platinum and palladium are the major platinum metals. The others, namely iridium, osmium, rhodium and ruthenium, are mainly used as alloying elements with platinum and palladium, but small amounts are also used in special applications.

A major new use for platinum and palladium resulted from the development of catalytic converters for installation on automotive vehicles for sale in the United States to meet the exhaust emission standards established by the Environmental Protection Agency (EPA) to reduce air pollution. Japan also has strict automotive emission control standards which generally require catalytic converters to attain them. Platinum and palladium catalysts are currently used on a limited scale in emission control systems where clean exhausts are required, and in catalytic incineration systems for fume abatement.

Platinum catalysts are used in the petroleum industry for the production of high-octane gasoline. The platinum catalytic exhaust control system in automobiles requires lead-free gasoline because lead fouls the catalyst and destroys its effectiveness. To obtain a satisfactory octane rating in non-leaded or low-lead gasoline requires further reforming, and thereby increases the demand for platinum alloy catalysts used in the process. A platinum-rhenium catalyst has been found to be effective in this application, but a drawback to its use is the small potential supply of rhenium metal.

Platinum catalysts find wide application in the chemical industry, the more important being in the production of nitric acid (by ammonia oxidation), hydrogen cyanide, benzene and sulphuric acid. They are also used in the hydrogenation of organic chemicals and in the pharmaceutical industry.

A platinum-rhodium alloy is used in bushings and spinnerets in the production of fibre glass and synthetic fibres, in electrical furnaces and in themocouples. The jewellery trade is a substantial consumer of platinum metals.

Platinum metals have many other applications, e.g., in the computer field, in electrical and laboratory equipment and in the dental and glass-making indus-

Table 3. World mine production of platinum group metals, 1973-75

	1973	1974	1975[e]
		(troy ounces)	
Republic of South Africa	2,362,800	2,835,000	2,700,000
U.S.S.R.	2,450,000	2,500,000	2,600,000
Canada	354,223	384,618	430,000
United States	19,980	13,000	16,000
Colombia	26,358	21,000	15,000
Other countries	26,420	19,000	20,000
Total	5,239,781	5,772,618	5,781,000

Sources: U.S. Bureau of Mines *Minerals Yearbook Preprint 1973* for year 1973 U.S. Bureau of Mines Commodity Data Summaries. January 1976 for 1974 and 1975; Statistics Canada for Canadian production.
[e]*Estimated.*

tries. Another application is in the cathodic protection of ships' hulls. A major use of palladium is in electrical contacts for telephone equipment, but the relatively high price of the metal has led to the use of substitutes in this application. Because of its resistance to corrosion at high temperatures, iridium crucibles are used for the growing of laser crystals and synthetic gems.

Prices

The worldwide decline in business activity in 1975 was reflected in lower prices for platinum, palladium, rhodium and iridium. During the year there were significant differences between dealer and producer prices. The producer platinum price at the beginning of 1975 was $190-200 U.S. an ounce and declined to $170-180 by February 14, and to $155-165 by April because of slumping demand. On July 29, the price was increased to $170-180 U.S. an ounce, partly because of an increase in speculative interest and indications that industrial demand would improve. Market forces caused the price to be cut back to $155-162 U.S. an ounce on October 10, where it remained for the balance of the year. The dealer price for platinum varied from $1 to $20 U.S. an ounce below that quoted by producers except for a short period during the first part of the year when the price differential was about $40 an ounce. It was quoted at $146 U.S. an ounce on December 31, 1975.

During most of 1975 there was a sharp variance between the producer and dealer prices of palladium, with the latter being much lower. The U.S.S.R. is the major world producer of palladium and, by maintaining its price of palladium at $150 U.S. an ounce, had a strong influence on the producer price remaining at a relatively high level.

The dealer price of palladium was under strong downward pressures throughout most of 1975. The demand for the metal dropped drastically because of reduced business activity and substitution of the metal by other materials. Some consumers sold excessive inventories. Towards the end of the year it was reported that the Russians had entered the market and were selling palladium at a price slightly above the dealer price. Russian palladium usually sells at a premium price because of better quality. The producer price of palladium at the beginning of 1975 was $150-155 U.S. an ounce and remained at this level until February 14, when it was lowered to $120-125 U.S. On June 2, the price was lowered to $80-85 U.S. an ounce. The dealer price of palladium was quoted at $107-118 U.S. an ounce at the beginning of the year and progressively declined to a price of $61 on June 2. On October 10, the producer price was lowered to $50-55 U.S. an ounce which was more in line with the dealer price, which had declined to $42-50 U.S. an ounce.

The producer prices of rhodium and iridium were quoted at $350-360 U.S. and $500-510 U.S. an ounce, respectively, at the beginning of 1975 and remained at these levels until October 10, when they were lowered substantially to $300-310 and $400-410 respectively because of poor industrial demand. The dealer price of rhodium declined from $500-550 at the beginning of 1975 to $375-450 later in January. By the end of 1975 it had further declined to $220 to 230 U.S. an ounce. The dealer price of iridium was $575-650 an ounce at the beginning of 1975 and progressively declined until by the end of the year it was being quoted at a price of $300-310 U.S. an ounce. The producer price for osmium and ruthenium remained unchanged during 1975 at $200-225 U.S. an ounce and $60-65 an ounce respectively. The dealer price for osmium dropped from $140-160 U.S. an ounce to $125-135 an ounce on October 2 and for ruthenium from $48-53 U.S. an ounce to $45-50 an ounce.

Outlook

The short-term outlook for platinum metals is for supply to be more than adequate to meet demand. Early in February 1975 the two major South African producers cut their rated yearly output by 25 per cent to ease a developing oversupply. In South Africa, unlike Canada and the U.S.S.R. where the platinum metals output depends on nickel production, the mine producers can adjust their platinum metals output to meet world requirements because their ores are mined primarily for platinum metals content.

It does not appear that there will be any marked resurgence in the demand for platinum metals in 1976 and the oversupply will continue. Representatives of the oil refining industry do not foresee any large increase in the demand for platinum metals in the near future. Major factors responsible for this outlook are technological developments which resulted in the production of more efficient catalysts using less platinum and increase to about 85 per cent in the recycling of platinum currently used in the oil industry, and cutbacks in refinery expansion programs. Also, many consumers have adequate stockpiles. In Japan, the jewellery trades consume the largest amounts of platinum, and demand in this field is expected to continue near the present rate.

The anticipated demand for platinum metals in catalytic converters will be affected by the Environmental Protection Agency's (EPA) decision to extend the interim standards now in effect to the automobile model-year 1977. The EPA also proposed that Congress extend the 1977 interim standards another five years to the model year 1982. The extension was proposed in order to evaluate possible environmental problems created by sulphate emissions produced by catalytic converters. Ford Motor Co. announced that all 1976 automobiles will have platinum metal converters. All automobiles manufactured after April 1, 1974 for sale in the Japanese market require platinum converters. The demand for platinum metals for use in catalytic converters in the United States in 1972 was about 370,000 ounces, each converter containing about 0.037 ounces of platinum and 0.012 ounces of palladium. Forecasts indicate that the output of automotive vehicles will increase significantly in 1976. The increased demand for platinum can be met from inventory stocks, or by South African producers restoring part or all of the production cutback.

The use of palladium declined in 1975 and no improvement in demand is expected in 1976. The sharp rise in the price of the metal between 1972 and 1974 forced consumers to search for ways to lower consumption in specific applications or to use substitute materials. Telecommunications has been a large consumer of the metal, but an alloy containing 60 per cent palladium and 40 per cent silver has reduced the use of palladium in its largest application in this field.

In the medium-to long-term view, sufficient platinum metals should be available to satisfy demand. The Merensky Reef deposits in South Africa will be able to meet normal increases in demand. Also the United

United States prices of platinum group metals 1975, as reported in Metals Week

	Producers	Dealers
	(U.S. $ per troy ounce)	
Iridium		
January 1 — January 15	500-510	575-650
January 16 — January 29	500-510	500-600
January 30 — February 26	500-510	425-550
February 27 — March 19	500-510	350-450
March 20 — April 30	500-510	450-500
May 1 — October 9	500-510	355-450
October 10 — October 22	400-410	355-375
October 23 — December 31	400-410	280-335
Osmium		
January 1 — October 1	200-225	140-165
October 2 — December 31	200-225	125-135
Palladium		
January 1 — February 10	150-155	107-118
February 11 — February 13	120-150	105-107
February 14 — April 16	120-125	83-101
April 17 — April 30	120-125	77- 83
May 1 — June 1	120-125	61- 72
June 2 — September 10	80- 85	52- 65
September 11 — October 9	80- 85	48- 52
October 10 — December 31	50- 55	42- 50
Platinum		
January 1 — January 9	190-200	162-166
January 10 — February 10	190-200	147-157
February 11 — February 13	170-190	147-159
February 14 — April 7	170-180	149-162
April 8 — July 23	155-165	143-158
July 24 —	155-165	165-169
July 25 — July 28	155-180	165-169
July 29 — September 3	170-180	166-171
September 4 — September 24	170-180	149-161
September 25 — October 9	170-180	141-152
October 10 — December 31	155-162	141-149
Rhodium		
January 1 — January 10	350-360	450-550
January 11 — January 22	350-360	375-450
January 23 — February 26	350-360	290-400
February 27 — October 9	350-360	245-330
October 10 — November 19	300-310	230-245
November 20 — December 31	300-310	210-235
Ruthenium		
January 1 — December 31	60- 65	45- 53

States stockpile contains an excess of 265,000 ounces of platinum, 926,000 ounces of palladium and 15,000 ounces of iridium which could be made available to the market in the future. The leading South African producers launched an advertising campaign to promote an increased use of platinum in the jewellery trade. It is too soon to determine the results of this promotion but to be competitive with gold in this application the platinum price must be maintained at such a level in relationship to gold that it can be used economically in place of gold. A new use for platinum could result from the successful development of a fuel cell as a source of power in which a platinum coated electrode acts as the catalyst for the direct conversion of chemical energy into electrical energy.

It is expected that palladium will be in oversupply for some time. Developments in the U.S.S.R., the world's largest producer of palladium, will substantially increase its output of the metal and the price should remain relatively stable. This anticipated price stability should encourage research in new applications for the metal as well as its increased use as a substitute for platinum and gold in technically-feasible applications.

Tariffs

Canada

Item No.		British Preferential	Most Favoured Nation	General	General Preferential*
36300-1	Platinum wire and platinum bars, strips, sheets or plates; platinum, palladium, iridium, osmium, ruthenium and rhodium, in lumps, ingots, powder, sponge or scrap	free	free	free	free
48900-1	Crucibles of platinum, rhodium and iridium and covers therefore	free	free	15%	free

*General Preferential Tariff rate from July 1, 1974 to June 30, 1984

United States

Item No.		Rate of Duty
601.39	Precious metals ores	free
605.02	Platinum metals, unwrought, not less than 90% platinum	free
		On and After Jan. 1, 1972
605.03	Other platinum metals, unwrought	20%
605.05	Alloys of platinum, semimanufactured, gold-plated	25%
605.06	Alloys of platinum, semimanufactured, silver-plated	12%
605.08	Other platinum metals, semimanufactured, including alloys of platinum	20%
644.60	Platinum leaf	20%

Sources: The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division Ottawa; Tariff Schedules of the United States, Annotated (1976) TC Publication 749.

Potash

B.W. BOYD

In 1975 world production of potash reached 26,625,000 tons* in spite of a general fall in production in noncommunist nations. In total, world production increased by 3 per cent over 1974 production of 25,788,000 tons and the increase was attributable to expansion of the U.S.S.R. potash industry. The trend of increased consumption was reversed so that for the first time in three years production exceeded consumption and prices began to fall toward the end of the year.

The bulk of world potassium production is in the form of potassium chloride (KCl) known in the industry as muriate of potash, used in the production of fertilizer. All Canadian potash production is marketed as the chloride, with a potassium content of about 50 per cent (60-62 per cent K_2O equivalent). This product is marketed in the United States, in offshore countries and domestically in the ratio of 68.6 per cent to 26.5 per cent to 4.9 per cent. The high percentage of exports leads to Canada's 34.7 per cent share of international potash trade.

Production and developments in Canada

Saskatchewan. There are ten potash mines in Canada (all in the province of Saskatchewan) with an installed productive capacity of 13,680,000 tons of potassium chloride (8,324,200 tons K_2O equivalent). In 1975 the industry operated at 72 per cent of capacity because slackening demand, especially in the offshore market, resulted in large inventories of product at the minesites.

Canadian production of 5,991,840 tons of potash in 1975 represents a decrease of 1 per cent from 1974 production, but in the same period shipments fell by 16 per cent to 5,346,000 tons. The value of potash shipments totalled $346,806,000, an increase of 12.2 per cent over the value in 1974 because the average realized price increased from $48.52 per ton K_2O equivalent in 1974 to $64.87 per ton in 1975. According to the Potash Institute of North America, producer stocks at the end of 1975 stood at 1,090,963 tons, four times the level of stocks at the end of 1974 and nearly as high as the record level at the end of 1972.

Potash prices varied greatly from company to company during the first half of 1975. Some companies raised their basic prices to accommodate the new reserves tax while other companies added a distribution charge or other surcharge to collect the extra revenue needed. However, by mid-year the surcharges were eliminated and the posted prices were set about 25 per cent higher than in 1974. In December 1975 discounts for shipments in the off-season were introduced by at least one company. The maximum discount obtainable was 4.5 per cent for shipment in December, 3 per cent for shipment in January and 1.5 per cent for shipment in February.

Production at several mines in Saskatchewan was interrupted in 1975 by strikes and fires. Strikes by locals of the United Steelworkers union occurred at Duval Corporation of Canada's mine and lasted for four months, at Potash Company of America's mine for three and one-half months, and at APM Operators Ltd.'s mine for three days. A fire on July 14 damaged the production headframe and electrical installations at the Hudson Bay Mining and Smelting Co., Limited mine near Rocanville. There were no injuries, but production did not resume for about three months. A fire at International Minerals & Chemical Corporation (Canada) Limited surface operations interrupted mine production for only one-half day but caused $5,000,000 damage to a new heavy media plant that was scheduled to open in January 1976. Fire destroyed the conveyor system used to unload potash from trains brought to Vancouver Wharves Ltd. in Vancouver. The fire did not affect the ship-loading facilities and exports were not affected.

New Brunswick. Two companies are exploring the potash resources in New Brunswick. Potash Company of America (PCA) had drilled 21 holes by year-end on its Sussex potash-salt property and is seeking an extension of its agreement with the New Brunswick govern-

*Unless otherwise noted, potash tonnages are in short tons of K_2O equivalent.

ment to permit further exploration. On September 30, International Minerals & Chemical Corporation (Canada) Limited (IMC) received a letter of intent signed by the province giving IMC rights for exploration and development of a potash prospect near Salt Springs, south of the property held by PCA. By year-end IMC had drilled two holes which intersected potash grading about 28 per cent K_2O at depths of less than 3,300 feet.

Ontario. Because of pollution control problems, the potassium sulphate plant of Shamrock Chemicals Limited, which opened in 1972, was inoperative for the third year in a row.

Government-industry relations

Planned increases in Saskatchewan potash production capacity by private industry have been postponed or cancelled because of uncertainty about Saskatchewan policy toward resource industries. The companies mining potash in the province claim that the "reserves tax", first imposed in 1974, coupled with the other provincial and federal imposts, lowers their rate-of-return on investment to a level at which expenditures for expansion cannot be justified.

All potash producers in the province are required to pay the reserves tax, federal and provincial income taxes, a proration fee, and a royalty on the ore. The "reserves tax" is based on the value of potash ore reserves, mine and refining plant. The amount of tax is determined by a complex formula involving the prevailing potash price, ore grade and productivity. The proration fee is $1.20 for each ton of product. The royalty is imposed for each ton of ore brought to the surface and is based on the concentration of potassium in the ore and the selling price of the product. Freehold owners of mineral rights must also pay an annual general levy of 50 cents an acre and an additional acreage tax of 10 to 40 cents an acre. Lessees of Crown mineral rights must pay an annual lease-rental fee.

In May, Mr. Justice D.C. Disbery, of the Court of the Queen's Bench ruled that Saskatchewan's potash "prorationing scheme" was unconstitutional and awarded Central Canada Potash Co. Limited $1,500,000 compensation plus costs. The ruling has been

Table 1. Canada, potash production, shipments and trade, 1974-75

	1974		1975^p	
	(short tons)	($)	(short tons)	($)
Production, potassium chloride				
Gross weight[1]	9,883,227	. .	9,802,298	. .
K_2O equivalent	6,041,143	. .	5,991,840	. .
Shipments				
K_2O equivalent	6,366,971	308,925,159	5,346,000	346,806,000
Imports, fertilizer potash				
Potassium chloride				
United States	330	48,000	371	90,000
United Kingdom	3	. . .	12	5,000
West Germany	11	5,000	–	–
Total	344	53,000	383	95,000
Potassium sulphate				
United States	24,396	1,396,000	11,461	940,000
West Germany	–	–	39	20,000
Total	24,396	1,396,000	11,500	960,000
Potash fertilizer, nes				
United States	56,920	1,670,000	49,007	2,365,000
Potash chemicals				
Potassium carbonate	1,632	369,000	1,140	405,000
Potassium hydroxide	2,153	468,000	6,557	1,334,000
Potassium nitrate	3,656	782,000	2,886	735,000
Potassium phosphate	3,801	1,435,000	3,190	1,591,000
Potassium bitartrate	76	152,000	176	273,000
Potassium silicates	937	184,000	1,051	306,000
Total potash chemicals	12,255	3,390,000	15,000	4,644,000

Table 1 (concl'd)

	1974		1975^p	
	(short tons)	($)	(short tons)	($)
Exports, fertilizer potash				
Potassium chloride				
United States	6,977,284	216,084,000	5,910,638	236,662,000
Japan	864,055	17,454,000	642,857	17,063,000
South Korea	259,561	5,503,000	380,827	10,544,000
Brazil	462,423	9,002,000	238,038	5,517,000
India	469,433	9,204,000	114,129	4,513,000
Australia	55,252	1,103,000	105,245	3,530,000
People's Republic of China	216,320	4,239,000	141,758	2,894,000
Bangladesh	8,822	171,000	46,265	1,912,000
Taiwan	117,445	2,570,000	61,112	1,597,000
Singapore	162,379	2,520,000	67,603	1,398,000
Philippines	37,383	735,000	41,823	1,245,000
Other countries	339,112	7,088,000	232,718	5,320,000
Total	9,969,469	275,673,000	7,983,013	292,195,000

Sources: Statistics Canada; Potash Institute of North America for K_2O production figures.
[1]Based on a conversion factor of K_2O x 1.64 for standard, special standard, granular and coarse grades, and K_2O x 1.60 for soluble and chemical grades.
^{p}Preliminary; — Nil; . . Not available; . . Less than $1,000.

appealed by the province. On October 2 the potash companies brought suit against the Saskatchewan government for return of some $24,000,000 in proration fees collected since June 1, 1972. In a separate action, 11 potash companies filed an action challenging the constitutionality of the reserves tax. The 11 companies also applied to the court to allow them to pay the reserve tax under protection of a court order ensuring return of the tax if it were declared unconstitutional. The application was turned down in September, but the decision is being appealed. Until the courts have settled the tax disputes, all the imposts are in effect.

Government actions

In November 1975 the Saskatchewan government unveiled a program by which it plans to expand the potash industry in the province, regulate production to conserve potash, and ensure a secure flow of revenue to all the people of Saskatchewan. On November 18, The Potash Development Act, 1975 and The Potash Corporation of Saskatchewan Act, 1975 were introduced in the provincial legislature. When enacted, the Development Act will enable the provincial government to purchase potash mines at a price negotiated between the province and the mine owners. The legislation will also allow the province to expropriate mines if a settlement cannot be reached. In the event of expropriation, price will be determined by a three-man board composed of representatives of the company concerned, the Potash Corporation of Saskatchewan and an independent opinion. The Potash Corporation will administer the mines taken over.

Immediately before the takeover announcement, the Potash Corporation of Saskatchewan obtained a one-year option to purchase a lease to potash rights on all property in Saskatchewan now held by Scurry-Rainbow Oil Limited of Calgary.

Table 2. Canada, summary of potash mines

Company and location	Initial Production	Production Capacity KCl	Production Capacity K_2O equiv.
		(000 tons*)	
Saskatchewan			
International Minerals & Chemical Corporation (Canada) Limited, Esterhazy	1962	2,100	1,280
	1967	1,720	1,050
PPG Industries Canada Ltd. Belle Plaine	1964	1,500	938
Potash Company of America, Saskatoon	1965	760	460
APM Operators Ltd., Allan	1968	1,500	912
Alwinsal Potash of Canada Limited, Lanigan	1968	1,000	600
Duval Corporation of Canada, Saskatoon	1968	1,200	732
Cominco Ltd., Vanscoy	1969	1,200	720
Central Canada Potash Co. Limited, Colonsay	1969	1,500	900
Hudson Bay Mining and Smelting Co., Limited, Rocanville	1970	1,200	732
Total		13,680	8,324

Source: Department of Mineral Resources, Saskatchewan.
*Short tons of 2,000 pounds.

Markets

About 95 per cent of the world's potash output is used for fertilizers, the balance being used for industrial purposes including the manufacture of soaps, glass,

Table 3. Canada, potash production and sales by grade[1] and destination, 1974-75

	1975						1974
	Standard[2]	Coarse	Granular	Soluble	Chemical	Total	Total
	(short tons K_2O equivalent)						
Production	1,995,506	2,188,439	1,199,913	512,053	95,929	5,991,840	6,041,143
Sales							
Domestic	14,888	211,156	4,656	5,052	15,314	251,066	294,373
United States	645,215	1,536,751	922,389	325,666	77,899	3,507,920	4,229,785
Offshore							
Australia	10,151	27,661	24,352	—	—	62,164	36,371
Bangladesh	—	10,086	7,949	—	—	18,035	4,264
Belgium	—	—	—	—	—	—	60,310
Brazil	54,466	65,259	6,719	—	—	126,444	307,075
Chile	—	—	—	12,961	—	12,961	10,449
Colombia	3,367	—	7,332	—	—	10,699	20,680
Costa Rica	3,319	2,818	—	—	—	6,137	11,096
Cuba	3,362	—	—	—	—	3,362	22,379
Ecuador	—	5,547	—	—	—	5,547	15,423
El Salvador	—	—	—	—	—	—	6,584
France	23,443	—	—	—	—	23,443	—
Guatemala	1,223	—	—	—	—	1,223	1,985
Guyana	—	—	—	—	—	—	710
India	82,017	—	—	—	—	82,017	277,720
Indonesia	—	—	—	—	—	—	32,140
Italy	—	—	—	10,782	—	10,782	10,085
Japan	284,809	71,688	—	72,323	—	428,820	501,933
Korea	271,311	26,407	—	—	—	297,718	198,063
Malaysia	48,061	2,592	1,138	—	—	51,791	63,813
New Zealand	31,377	—	—	—	—	31,377	10,838
People's Republic of China	90,340	—	—	—	—	90,340	137,939
Peru	7,060	—	—	—	—	7,060	7,748
Philippines	26,135	—	—	—	—	26,135	22,996
South Africa	—	10,196	—	—	—	10,196	3,420
Sri Lanka	—	—	3,340	—	—	3,340	—
Taiwan	36,550	—	—	—	—	36,550	77,134
Thailand	3,374	—	—	—	—	3,374	337
Turkey	—	—	—	—	—	—	51
United Kingdom	3,007	—	—	—	1,220	4,227	1,305
Viet Nam	—	—	—	—	—	—	2,718
Offshore Total	983,372	222,254	50,830	96,066	1,220	1,353,742	1,845,566
Total Sales	1,643,475	1,970,161	977,875	426,784	94,433	5,112,728	6,369,724

Source: Potash Institute of North America.
[1]Common specifications are: standard -28 to+65 mesh, special standard -35 to+200 mesh, coarse -8 to+28 mesh, granular -6 to+20 mesh, each grading a minimum of 60 per cent K_2O equivalent, soluble and chemical grade a minimum of 62 per cent K_2O equivalent. [2]Standard includes Special Standard, production of which was 247,432 short tons K_2O equivalent in 1975 and 332,903 in 1974.
— Nil.

ceramics, textiles, dyes, explosives and numerous chemicals.

In Canada, consumption totalled 227,000 tons of potash in 1975, with all but 10,000 tons of this being used as fertilizer. Deliveries of Canadian potash to consumers in Canada totalled 251,000 tons, distributed mainly to farm communities in southern Ontario, Quebec and the Maritime Provinces.

The United States imported 65.6 per cent of Canadian potash shipments and final deliveries reached nearly every state in the union. The 3,507,920 tons imported represented a 17 per cent decrease from shipments in 1974 and amounted to 69 per cent of the potash distributed in the United States market. The six states consuming the most potash; Illinois, Iowa, Indiana, Ohio, Minnesota and Georgia, are supplied chiefly from Canada, as are eight of the 12 other major potash-consuming states (over 100,000 tons K_2O equivalent each, annually). The portion of the market not served by Canada is supplied from potash mines in New Mexico, Utah and California, and by imports mainly from Israel.

Offshore sales of Canadian potash fell by 26.6 per cent to 1,353,742 tons in 1975 in response to a worldwide decrease in demand for fertilizer. Market changes which most affected Canada occurred in Brazil, India and Japan. The Brazil market is now supplied by the United States which, by loading ships at Houston on the Gulf of Mexico, has a shipping advantage relative to Canadian producers shipping potash out of Vancouver. The markets in India and Japan declined in 1975 and the Indian market became increasingly dominated by Eastern European and Western European producers.

Imports of potassium chloride into Eastern Canada remained very low at 383 tons KCl well below the peak reached in 1972 when 69,120 tons were shipped from the United States. Imports of potassium sulphate were halved to 11,500 tons K_2SO_4 and imports of potash fertilizers other than KCl or K_2SO_4 fell by 7,000 tons to total 49,000 tons. Imports of potassium chemicals totalled 15,000 tons, an increase of 3,000 tons over the stable level maintained during the previous four years.

Table 4. Posted prices for muriate of potash

Grade and % K_2O min.	Jan. — June/75	July — Aug./75	Sept./75 Jan./76
	(cents/short ton unit, fob Saskatchewan)		
Standard 60-62	57-69	65	70
Coarse 60-62	61-73	68	73
Granular 60-62	63-75	70	75
Soluble 62	63-75	70	75

Source: Price schedules of various potash companies.

Table 5. Canada, potash production and trade, years ended June 30, 1966-75

Year Ended June 30	Production	Imports[1]	Exports
	(short tons K_2O equivalent)		
1966	1,927,843	34,522	1,676,174
1967	2,204,231	38,090	2,004,504
1968	2,971,206	32,900	2,723,471
1969	3,085,995	24,600	2,620,672
1970	3,930,662	27,020	3,648,384
1971	3,422,430	28,010	3,319,284
1972	4,151,105	50,740[r]	3,974,278
1973	3,994,685	81,120[r]	3,889,330
1974	5,376,851	40,795	5,233,648
1975[p]	5,581,702	36,563	5,052,607

Source: Statistics Canada, Fertilizer Trade.
[1] Includes potassium chloride, potassium sulphate, except that contained in mixed fertilizers.
[p] Preliminary; [r] Revised.

External Development

On December 16, 1975 the United States Treasury Department modified its antidumping finding of December 1969 to tentatively revoke the finding of dumping of potassium chloride from Cominco Ltd. Since May 1974 the finding of dumping has been modified to exclude the eight other Canadian exporters originally charged. A final revocation of dumping findings on potassium chloride from Canada could be announced in 1976.

World review

Potash is used chiefly in mixed fertilizers with ammonia and phosphate compounds. In the past two

Table 6. Canada, consumption of potash fertilizers, year ended June 30, 1966-75

	In Materials	In Mixtures	Total
	(short tons of K_2O equivalent)		
1966	20,644	135,695	156,339
1967	27,806	150,336	178,142
1968	34,771	148,329	183,100
1969	40,967	144,560	185,527
1970	40,475	152,004	192,479
1971	46,831	156,362	203,193
1972	48,340	226,057	274,397
1973	45,974	164,246	210,220
1974	48,870	173,840	222,710
1975	69,385	157,583	226,968

Source: Statistics Canada.

years the price of ammonia has increased steadily with the increasing cost of natural gas. In the same period the price of phosphate rock quintupled. As a result, the world price of fertilizer products has increased threefold and, consequently, farmers have been unable to buy as much fertilizer as in the past. With the fall in demand for mixed fertilizer, potash sales have declined, notwithstanding the relatively slow rise in potash prices.

In 1975, and for the sixth consecutive year, the U.S.S.R. ranked as the world's largest potash producer. Although the objectives of the five-year plan just ended were not reached, production for 1975 in the U.S.S.R. totalled 8,708,000 tons an increase of 4 million tons in five years. New mines have been opened in the main producing areas in the Urals and Belorussiya.

Table 7. Canada, potash deliveries by product and area, 1974-75

		Agriculture							
		Potassium Chloride					Potassium		
		Standard	Coarse	Granular	Soluble	Potassium Sulphate	Magnesium Sulphate	Total Agriculture	Industrial
		(short tons K_2O equivalent)							
Alberta	1974	278	2,029	3,100	1,956	—	91	7,454	1,873
	1975	916	1,716	2,437	1,220	25	101	6,415	3,725
British Columbia	1974	31	6,273	924	14	133	349	7,724	233
	1975	—	5,239	291	60	249	207	6,046	179
Manitoba	1974	169	1,816	3,718	25	20	6	5,754	—
	1975	89	1,370	884	12	—	26	2,381	214
New Brunswick	1974	1,304	9,636	—	—	—	734	11,674	—
	1975	304	9,152	—	—	25	315	9,796	—
Northwest Territories	1974	—	—	—	—	—	—	—	1,652
	1975	—	—	—	—	—	—	—	900
Nova Scotia	1974	—	4,841	—	31	174	39	5,085	—
	1975	98	4,415	—	—	—	33	4,546	—
Ontario	1974	5,760	136,857	5,871	101	11,382	5,914	165,885	5,780
	1975	1,243	179,787	979	356	6,143	4,373	132,881	5,329
Prince Edward Island	1974	—	13,269	—	—	400	718	14,387	—
	1975	—	8,567	—	—	81	49	8,697	—
Quebec	1974	4,857	54,393	1,812	—	2,861	2,552	66,475	187
	1975	5,212	60,595	(-61)	—	1,472	1,898	69,116	147
Saskatchewan	1974	—	134	62	—	—	—	196	14
	1975	48	315	126	—	—	—	489	205
Totals	1974	12,399	229,248	15,487	2,127	14,970	10,403	284,634	9,739
	1975	7,910	211,156	4,656	1,648	7,995	7,002	240,367	10,699

Source: Potash Institute of North America.
— Nil.

Production began at a new 2.5 million-ton-a-year potash mine/concentrator at Solikamsk in the Perm Oblast and construction continued on potash mine/concentrators at two other sites in this area that will have a total capacity of 14 million tons of KCl. Expansion is reportedly continuing in the Belorussiya potash mining area as well. Problems in delivery of potash to domestic consumers have arisen from shortages of covered railway cars and storage space.

In the Hashemite Kingdom of Jordan, development continued on construction of a 1-million-ton-a-year potash extraction plant beside the Dead Sea; completion is expected in 1981.

A large potash prospect said to cover 30 square kilometres has been discovered in Laos. Detailed evaluation of the prospect has not yet taken place. A salt bed 400 metres thick, with potassium minerals in the upper levels, has been discovered in Turkmeniya S.S.R. but details on size and mineralogy are not available.

Outlook

In the near-term, world sales of potash are expected to increase beyond the level reached in 1974 as consumer stockpiles are depleted and the fall in phosphate prices takes effect. The North American market will likely return to normal in the spring of 1976. Production in Saskatchewan will be constrained to the present industry capacity, but the 1 million tons in storage at the end of 1975 will allow sales to exceed 7 million tons K_2O equivalent in the new year. A medium-term growth rate of some 5 per cent annually is probable for world potash consumption. Expansion of the industry in Saskatchewan must be initiated soon if Canada is to maintain its share of the total world market.

Table 8. World potash production, sales and inventories, 1973-75

	1973		1974		1975[p]	
	Production	Sales	Production	Sales	Production	Sales
	('000 short tons K_2O equivalent)					
U.S.S.R.	6,522	6,510	7,260	7,025	8,708	8,378
Canada	4,698	5,277	6,041	6,369	5,992	5,112
East Germany	2,818	2,789	3,157	3,156	3,325	3,325
West Germany	2,808	2,815	2,888	2,923	2,450	2,348
United States	2,603	2,685[r]	2,552	2,545	2,501	2,109
France	2,239	2,157	2,285	2,344	2,104	1,984[1]
Israel	585	948	669	1,213	551[e]	. .
Spain	523[r]	. .	436	. .	507	. .
Congo	292	284	314	308	315	. .
Italy	147[r]	. .	166	. .	. .	. .
Others	—	293[r]	20	67	172	1,172
Total	23,235[r]	23,758[r]	25,788	25,950	26,625	24,428

Year-end producer inventories

	1973	1974	1975[p]
Canada	531	132	1,091
United States	195	205	632

Sources: Potash Institute of North America, U.S. Bureau of Mines, World Mining, Phosphorus and Potassium and World Survey of Potash Resources.
[1] 1975 French sales figure includes sales from Congo.
[p] Preliminary; [r] Revised; [e] Estimated; — Nil; . . Not available.

Rare Earths

G.E. WOOD

The rare earth elements, sometimes called the lanthanons or lanthanides, are a group of 15 chemically similar metals having atomic numbers 57 to 71 in Group III of the periodic table of elements. Scandium and yttrium are similar to the rare earth elements in many respects and are usually classed with them.

These elements are neither rare nor earths. By comparison, cerium is more abundant than tin or cobalt and almost three times as abundant as lead. Thulium, less common than all other rare earths except promethium, is more abundant than silver, gold and platinum combined. The metals were originally classified "rare" because they are seldom concentrated in nature like most other elements and their widespread occurrence in the earth's crust was recognized only in recent times. The term "earth" is derived from earlier terminology when insoluble oxides, the common compounds of rare earths, were simply referred to as earths.

Lanthanon-bearing minerals contain all members of the rare earth elements, but either the light (cerium) group or the heavy (yttrium) group predominates in each mineral. The rare earth metals are typically associated with alkaline complexes and pegmatites; and secondary concentration can occur in placer, beach sand, and phosphatic sedimentary deposits. Commercial production has been derived from carbonatite occurrences, placer, and beach sand deposits, uranium ores and phosphatic rocks. The relative abundance of the various rare earths in the ores presently being mined is not directly related to the market demand for the individual products. As a result, some rare earths products are readily available at low cost, while others, particularly high-purity metal and compounds, are considerably more expensive. Research continues to explore the properties of the rare earth metals to identify potential new markets but, for some, no significant use has yet been found. Development has proceeded; first, to find markets for those compounds that are available and, second, to find and develop sources of supply to meet changing industrial requirements.

Advances in new markets have occurred at two- to three-year intervals for the past decade. Beginning with the traditional cigarette lighter flints and carbon-arc markets, new uses have grown in glass polishing compound, petroleum catalyst, television tube phosphor, nodular iron, high-strength, low-alloy steel and high-strength magnet applications.

When colour television was introduced, the forecast for europium and yttrium consumption in phosphors was one of optimism which led to over-production by 1967. Part of the problem was a slower-than-anticipated growth in the television market. A second factor was the overestimate of the quantity of rare earth metals to be used in each television set.

New types of permanent magnets using rare earth elements together with cobalt have unusually high strength, or conversely, relatively low weight and bulk for a given strength. These magnets are beginning to find wide industrial application in automotive motors and machine tools. Canadian production of rare earths since 1967 has undergone drastic adjustments; yttrium concentrate suppliers have reduced shipments each successive year until 1971, when deliveries stopped. Shipments of yttrium concentrate from one Canadian producer were resumed in 1973 and continued in 1974 and 1975.

New markets for specific members of the rare earth group have resulted in increased production of all rare earth metals because of their natural association in ores. Similarly, production costs for some rare earth members, byproducts of the refining process, have diminished. Availability and declining costs have been important factors in the development of new uses. There is growing optimism that the rare earth metals industry will expand at a steady rate now that industrial uses are becoming more diverse.

Canadian industry

From 1966 to 1970, the world's major source of yttrium concentrate was the uranium mines in the Elliot Lake District of Ontario. All rare earths, except promethium, have been detected in these ores. The

Elliot Lake ores contain about 0.11 per cent uranium oxide (U_3O_8), 0.028 per cent thorium oxide (ThO_2) and 0.057 per cent rare earth oxides (REO).

Denison Mines Limited (Denison), which resumed the production and shipment of yttrium concentrate in 1973, continued to produce in 1975. Under a contract negotiated with a United States company, Molycorp Inc. (Molycorp), Denison has a commitment to ship yttrium concentrate to Molycorp until March 1977. Denison had previously shipped yttrium concentrate to Michigan Chemical Corporation, but production was terminated in mid-1970 when the company experienced difficulty in marketing the product. Denison shipped some concentrate in 1971, but the quantity and value was not reported.

During 1966 and 1967, Rio Algom Limited recovered thorium and rare earth concentrate at its Nordic mill, but did not resume production when the milling of uranium ores was transferred to the Quirke mill.

Rare earth elements, primarily the light element group, are associated with apatite in the Nemegos No. 6 magnetite deposit, which is located in the Chapleau area of Ontario. Multi-Minerals Limited is seeking to develop the deposit, and continued in 1975 to make efforts to determine the feasibility of promoting an integrated complex which would produce pig iron, phosphoric acid and rare earth products.

Table 1. Rare earth elements

Atomic No.	Name	Symbol	Abundance in Igneous Rocks
	Light rare earths		(parts per million)
21	Scandium	Sc	5.0
57	Lanthanum	La	18.3
58	Cerium	Ce	46.0
59	Praseodymium	Pr	5.5
60	Neodymium	Nd	23.8
61	Promethium	Pm	(Not measurable)
62	Samarium	Sm	6.5
63	Europium	Eu	1.1
64	Gadolinium	Gd	6.3
	Heavy rare earths		
39	Yttrium	Y	28.0
65	Terbium	Tb	0.9
66	Dysprosium	Dy	4.5
67	Holmium	Ho	1.1
68	Erbium	Er	2.5
69	Thulium	Tm	0.2
70	Ytterbium	Yb	2.6
71	Lutetium	Lu	0.7
		Total	153.0

Table 2. Canadian shipments of rare earth concentrates

	Y_2O_3 in Concentrates	Values
	(pounds)	($)
1975[1]	77,000	. . .
1974	86,788	. . .
1973	. . .	. . .
1972	—	—
1971	. . .	. . .
1970	73,000	657,000
1969	85,443	671,500
1968	113,330	936,067
1967	172,551	1,594,298
1966	20,724	130,223

. . . Statistics withheld; — Nil. [1]Taken from 1975 Annual Report, Denison Mines Limited.

In addition to the large reserves in Elliot Lake uranium ores, rare earths are also associated with uranium deposits at Agnew Lake, 40 miles east of Elliot Lake, where the rare earth oxide (REO) content is about twice that of Elliot Lake ores, and in the Bancroft area of Ontario.

Agnew Lake Mines Limited dewatered the Agnew Lake uranium mine during 1974 and is preparing the mine for production in 1977 by a method of underground leaching. The orebody has a relatively high content of cerium associated with the uranium.

Phosphorite formations in western Canada contain small quantities of rare earths, as do Florida phosphates imported into Canada for the production of phosphoric acid. Other potential sources include apatite-rich carbonatites.

Shipments of rare earth concentrates since 1966 are summarized in Table 2. Statistics for 1971 and 1973 have been withheld to avoid disclosing individual company confidential data.

Denison Mines Limited, the only Canadian producer of rare earth metals in 1975, reported to its shareholders that it produced 86,788 pounds of yttrium oxide in 1974 and 77,000 pounds in 1975.

World industry

The minerals monazite and bastnaesite are the main source of the cerium group of rare earths. These are processed to recover mixed rare earths for low-value products such as mischmetal, or further processed at much higher cost to separate individual rare earths.

Monazite recovery is a byproduct of mining beach sands for rutile, zircon and ilmenite. Australia, India, Brazil, Malaysia and the United States, soon to be joined by South Africa, are the principal producers. In the United States, monazite is recovered from beach sands in Georgia and Florida.

Table 3. Principal world processors of rare earth ores and concentrates

Austria
- Treibacher Chemische Werke Aktiengesellschaft

Belgium
- S.A. de Pont-Brulé

Brazil
- Commissao National de Energia Nuclear (Industrias Quimicas Reunidas)

Britain
- British Flint and Cerium Manufacturers Limited
- British Rare Earths Limited
- London and Scandinavian Metallurgical Company,
- Rare Earth Products Limited (a Thorium Ltd. and Johnson Matthey Chemicals Limited joint venture)

Finland
- Kemira Oy

France
- Rhône-Poulenc, Etablissements Tricot

West Germany
- Otavi Minen und Eisbahn Ges.
- Th. Goldschmidt A.G.

India
- Indian Rare Earths Limited

Japan
- Ogino Chemical Company
- Nippon Yttrium Company
- Santoku Metal Industry Company
- Shin-Etsu Chemical Industry Company
- Wako Bussan Company

Norway
- A/S Metal Extractor Group of Norway (Megon)

United States
- American Potash and Chemical Corporation
- Lindsay Rare Earth Division[1]
- Michigan Chemical Corporation
- Molycorp Inc.
- Nucor Corp., Research Chemicals Division
- Rare Earth Metal Company of America
- Reaction Metals Inc., a subsidiary of Rare Earth Industries, Inc.
- Ronson Metals Corporation, Cerium Metals & Alloys Division
- W.R. Grace and Company, Davison Chemical Division
- Gallard-Schlesinger Chemical Manufacturing Corp., Atomergic Chemetals Co. Division
- Transelco, Inc.

U.S.S.R.
- State controlled. Output is sold through Techsnabexport

[1]The Company's processing facilities located in West Chicago were closed in 1973.

The Molycorp mine at Mountain Pass, California, is the main source of concentrates for cerium-group rare earths and, unlike monazite, bastnaesite concentrates from this unusual deposit in carbonatite do not contain thorium. The ore, mined in a small, low-cost open pit, grades 8 to 10 per cent rare earth oxides. The rare earth distribution in per cent oxide is: cerium, 50.0; lanthanum, 33.0; neodymium, 12.0; praseodymium, 4.0; samarium, 0.5; gadolinium, 0.2; europium 0.1 and yttrium group, 0.2. The adjacent mill produces a flotation concentrate grading 60 per cent rare earth oxide, a leached concentrate grading 70 per cent, a calcine grading 90 per cent, and seven modified concentrates. A chemical and solvent extraction plant makes intermediate rare earth products and separates a number of rare earths, including europium. Further processing is carried out at Louviers, Colorado; York, Pennsylvania and Washington, Pennsylvania.

Production from the Mountain Pass mine in 1975 amounted to 33 million pounds of REO, compared with 44 million pounds in 1974. The decline in production reflects the world economic recession of 1975. The Mountain Pass mill can now produce approximately 60 million pounds of REO annually and the chemical plant can process 30 million pounds.

Rare Earth Metal Company of America (REMCOA), a joint venture of Aluminum Company of America (Alcoa) and Molycorp, began construction in 1975 of a 250,000-pound-a-year demonstration cell for the electrolytic production of mischmetal* at Arnold in Pennsylvania. The plant will treat concentrates from the Mountain Pass mine.

A former Australian rare earth metals producer may resume production in the near future. The mine, operated by Mary Kathleen Uranium Limited, produced uranium and a rare earth concentrate until 1963. Uranium production will be resumed early in 1976. Total reserves at the mine, including tailings, contain some 400,000 tons of REO. At a planned annual mining rate of 900,000 tons of ore, the mine could recover about 5,000 tons a year of REO contained in concentrate.

Mitsubishi Chemical Industries Ltd. of Japan and Beh Minerals Sendirian Berhad of Ipoh, Perak State, Malaysia have set up a joint company, Malaysian Rare Earth Corp. (MAREC), to produce rare earth oxides containing a minimum of 60 per cent yttrium oxide from Malaysian xenotime. About 60 per cent of production, initially 10 tons a month, will be exported, mainly to Japan.

Japanese demand for REO has increased greatly in recent years. Molycorp has made an agreement with Mitsubishi International, Inc. whereby the latter company will act as sales agent for Molycorp's REO sales in Japan.

Following the completion of its full-scale facility for the production of high-purity yttrium oxide, A/S Megon & Co., (Megon), is now participating in a joint venture with Malaysian interests to construct and

*The composition of mischmetal is described in the section on consumption and uses.

operate a concentrator near Kuala Lumpur in Malaysia. The plant has a design capacity of 30 tons a year of 60 per cent Y_2O_3 concentrate and was expected to be completed late in 1975.

The mineral xenotime, valuable for its yttrium content, is recovered from heavy mineral rejects of the Malaysian tin industry and from retreatment of monazite concentrate, itself a byproduct, from Western Australia.

Some uranium ores contain the rare earth elements and are an important source for the yttrium group. Solution liquors, following uranium and thorium extraction, are treated to recover the rare earth elements. Canadian production, and potential production in Australia; the Mary Kathleen Uranium Limited and Field Metals and Chemicals Pty. Limited deposits, are of this type. The rare earth minerals euxinite, samarskite and fergusonite are another source of the yttrium group, but they are difficult to treat.

Promethium isotopes have half-lives ranging from seconds to 18 years and, therefore, are rare in nature. The commercial source of promethium 147 is from waste fission products in atomic reactors. Its radioactive properties are attractive as a power source in space research as well as in luminescent paints.

Consumption and uses

World consumption of rare earth metals, after approximately doubling in the period 1971-1973, and increasing further in 1974, recorded a decline in 1975. In the United States, leading applications of rare earth materials were in catalysts in petroleum refining, as additives in steel and nodular iron, carbon arc electrodes, ceramics and glass, in lighter flints and in colour television phosphors. Use of rare earth metals in permanent magnets increased in 1975.

Mischmetal is a suitable nodulizing alloy that promotes ductility in cast iron by neutralizing the harmful effects of trace elements which inhibit the formation of nodular graphite. The ductile iron industry has realized significant cost savings through the substitution of mischmetal for more expensive additives.

Mischmetal, the primary commercial form of mixed rare earth metals, is prepared by the electrolysis of fused rare earth chloride mixtures. Mischmetal contains 94-99 per cent rare earth metals plus traces of calcium, carbon, aluminum, silicon and iron. A typical composition is 52 per cent cerium, 18 per cent neodymium, 5 per cent praseodymium, 1 per cent samarium, 24 per cent others, including lanthanum. Some grades are nearly free of cerium. Ferrocerium is an alloy of mischmetal and iron.

In recent years, the practice of adding some three pounds of mischmetal or rare earth silicides to each ton of high-strength low-alloy (HSLA) steels has become general to counter the deleterious effects of sulphur. The conventional method of treating undesirable sulphur is to combine it with magnesium, but magnesium sulphide elongates when rolled and the resulting steel is weaker in the transverse direction. The addition of rare earths results in a HSLA steel that is nearly equally strong in the transverse and longitudinal directions. HSLA steels are being used increasingly in gas and oil pipelines, automobiles, trucks, trains, ships, and construction equipment. Mischmetal has a stable market in lighter flints. However, the lighter flint market is becoming a less important outlet as mischmetal applications grow in the iron and steel metallurgical fields.

The other major use of the rare earth group is for catalysts in the cracking operation of petroleum refining. Although naturally mixed elements were originally used in catalysts, the trend has been to chloride mixtures of lanthanum, neodymium and praseodymium. Relative consumption in this field has been declining in recent years. Palladium is a substitute for the rare earth elements in petroleum refining catalysts.

The third most important market for rare earth metals, in terms of volume, is the glass polishing industry. Commercial-grade cerium and mixed rare earth oxides are used extensively in optical, mirror and plate glass polishing. Plate glass polishing has been reduced since the introduction of the Pilkington float glass process, but there is no comparable substitute for rare earth oxide compounds in high-quality optical polishing.

The glass industry employs rare earth additives for their many unique characteristics. Cerium oxide, in small quantities, is an effective glass decolourizer. Due to their ability to absorb ultraviolet light, cerium and neodymium oxides are used in transparent bottles to inhibit food spoilage and in welders' goggles, sunglasses and optical filters. For glass colouring, praseodymium imparts a yellow-green colour, neodymium a lilac, europium an orange-red, and erbium a pink colour. Lanthanum is a major component of optical glass, and cerium glass is used for windows in atomic reactors.

Rare earth oxides and fluorides are used in significant quantities in carbon-arc lamps where a high-intensity white light is desirable.

A high-value application is in the electronics field where rare earth oxides are used as phosphors in colour television tubes, temperature-compensating capacitors and associated circuit components. Although the volume of europium and yttrium oxides used in colour television phosphors is comparatively small, the value is disproportionately large because of the high degree of purity required in this application. Minor quantities of the rare earth group are used in laser materials, atomic fire extinguishers, nuclear reactor absorption and shielding materials, magnesium and aluminum alloys, brazing alloys, low-corrosion alloys, gemstones, self-cleaning oven catalysts, ceramic and porcelain stains and microwave controls.

An important new market is rare earth-cobalt permanent magnets (RE magnets). Samarium-cobalt permanent magnets are now in use that have many times the strength of any conventional permanent magnet. These magnets are usually fabricated by powder metallurgical methods, which facilitate the procedure for inducing a high magnetic flux. High-strength permanent magnets are used in special applications, such as aerospace equipment, where the greater cost can be justified in terms of better performance. Recent research has led to the development of less-expensive RE magnets. Part of this improvement has resulted from better manufacturing techniques, but a more significant development is the substitutions of mischmetal for some more expensive samarium in magnets. Considering all the developments that have occurred within the few years since RE magnets were first discovered, the trend indicates a strong growth rate in use of these magnets for the next several years in electric motors, generators, meters, speakers and frictionless bearings. By 1975 United States automobile manufacturers were seriously studying the application of mischmetal-cobalt magnets, in a range of sizes, for use in fuel gauges, electronic ignition systems, windshield wipers, window and seat drives, starter motors and in new developments such as continuous monitoring of tire pressures. Full realization of these potential uses will depend upon further cost and weight reduction, assured availability of cobalt and utilization of other rare earth metals than samarium.

Rare earth metals catalysts have been identified as possible inexpensive alternatives to platinoid catalysts in automobile exhaust converters. The rare earth-based converters have shown promise in reducing carbon monoxide and nitrogen oxide emissions, but more research is necessary. Initially, the automotive industry opted for platinum-based systems to meet emission control standards set for U.S. vehicles in 1975.

Research on rare earth metals uses has taken many directions and some of the more promising investigations are indicated below. Lanthanum-nickel alloy has been suggested as a storage medium for hydrogen under low pressure. Investigations have shown that an equal volume of hydrogen can be stored in one third the space required for liquid hydrogen, and can be released safely. Hydrogen is being considered as a future fuel. The International Nickel Company of Canada, Limited has developed a dispersion-hardened alloy containing 0.5 per cent yttrium oxide. This alloy is considered to be superior to conventional alloys because it can withstand higher temperatures. The company anticipates application in aircraft engine vanes used to guide hot gases against turbine blades. Europium hexaboride, used as a long-lived nuetron absorber, is being promoted as a control in the upcoming generation of fast breeder nuclear reactors. Gadolinium oxide is currently used as a control in existing light water reactors.

Prices

The December issue of *Industrial Minerals* (London) quotes 70 per cent leach bastnaesite concentrates, per pound REO at 55-65 cents; Australian monazite, miminum 55 per cent REO, a long ton fob Australia, $A 175-185; Malayan xenotime concentrate, minimum 25 per cent Y_2O_3 a pound cif $ U.S. 2-3.

The prices per pound of pure rare earth metals of the lanthanide group as used in permanent magnets, at year-end were as follows: lanthanum, $25.00; cerium, $18.00; samarium, $69.00; mischmetal, 99.8%, $3.45; mischmetal (no Ce), $12.00.

Rare earth oxide prices, per pound, as quoted in *American Metal Market*, 26 December 1975 issue were as follows: europium 99.99%, $500-550; lanthanum 99.9%, $6.00; cerium 99.9%, $5.50-7.00; neodymium 99.9%, $20.00-$25.00; praseodymium 99%, $30; yttrium 99.99%, $33-36; gladolinium 99.9%, $52-55; samarium 99.9%, $35.

Rhenium

J.J. HOGAN

Rhenium is a relatively new metal which was first isolated in 1925. It occurs principally in low-grade porphyry copper ores containing molybdenum and is recovered as a byproduct from the treatment of molybdenum concentrates. The rhenium content in porphyry copper ore is only a few parts per million (ppm) whereas the molybdenite concentrates produced from these ores have a rhenium content varying from 300 to 2,000 ppm. Rhenium has been identified in some molybdenum, manganese and uranium ores, but in concentrations too low to be of economic significance under present technology and price structure.

Canadian rhenium production comes from the copper-molybdenum ore of Utah Mines Ltd. (Island Copper mine) at Port Hardy, Vancouver Island, British Columbia. The ore occurs mainly in altered volcanics and, in this respect, differs from the porphyry copper deposits which have been the major source of rhenium in the United States and Chile. The metal has also been identified in the porphyry copper ores of Lornex Mining Corporation Ltd. and Brenda Mines Ltd., near Kamloops, British Columbia.

The United States, the largest producer of rhenium metal and salts in the noncommunist world, recovered rhenium mainly from porphyry copper ores in the western states. The producers of rhenium in the United States in 1975 were Cleveland Refractory Metals, Inc. (CRM) of Solon, Ohio, a division of Chase Brass & Copper Co. Incorporated (a subsidiary of Kennecott Copper Corporation); S.W. Shattuck Chemical Co., of Denver, Colorado, a division of Engelhard Minerals & Chemicals Corporation; M & R Refractory Metals, Inc. of Winslow, New Jersey, and Molycorp Inc. of Washington, Pennsylvania.

Chile recovered rhenium from molybdenite concentrates produced as a byproduct from its large porphyry copper ore deposits. According to data published by the United States Bureau of Mines, the United States, during 1975, imported into bonded warehouses substantial quantities of ammonium perrhenate (NH_4ReO_4) from Chile. In 1974, Chile first started exporting ammonium perrhenate to the United States which is used in that form by industry or can be further processed to rhenium powder. In previous years, rhenium exported to the United States was contained in molybdenite concentrates shipped there for treatment.

Other countries which have metallurgical plants to recover rhenium are the U.S.S.R., Sweden, Belgium, Holland and West Germany. With the exception of the U.S.S.R., these countries recover rhenium from molybdenite concentrates imported from Chile, Peru, Canada and Zaire.

Production

Rhenium is a recent addition to the metals produced in Canada, with production first being recorded in 1972. Utah Mines reported that the rhenium contained in the molybdenite concentrates produced in 1975 at its Island Copper mine varied between 1,100 and 1,500 ppm, and averaged about 1,281 ppm. In 1975 shipments of molybdenite concentrates to refineries in the United States and Western Europe totalled approximately 1,637 short tons. The rhenium contained in the concentrates shipped by Utah Mines was treated on a toll basis at the receiving smelters and the recovered rhenium was returned to the company as perrhenic acid for subsequent sale. Under present technology, the recovery of rhenium contained in molybdenite concentrates is in the range of 50 to 60 per cent. Based on the above shipments and the estimated recovery and grade, the rhenium recovered from Canadian ores in 1975 was in the order of 2,100 pounds.

Statistical data on world output and total value of rhenium are not available. Rhenium production in the United States was estimated at 5,000 pounds in 1975 by the U.S. Bureau of Mines, compared with 6,700 pounds in 1974. The United States consumption of rhenium was estimated at 4,600 pounds in 1975, compared with 4,500 pounds in 1974. About 80 per cent of the rhenium consumed in the United States in 1975 was used in the fabrication of bimetallic platinum-rhenium catalysts for the petroleum refining industry. Chile is believed to be the next largest producer. The U.S.S.R., also a substantial rhenium producer, recovers rhenium from molybdenite concentrates obtained from its porphyry copper deposits, and its production was estimated at 2,000 pounds in 1975 by the U.S. Bureau of Mines.

Rhenium is recovered from flue gases emitted from the roasting of byproduct molybdenite concentrates. Under properly controlled temperature conditions rhenium volatilizes as rhenium heptoxide (Re_2O_7) which is readily soluble in an aqueous solution. Flue-dust particles carrying about 10 per cent of the rhenium contained in the roaster feed are re-cycled to the roaster. Before flue-gas technology was developed, flue-dust was the major source of the metal. To extract the rhenium, flue gases are cleaned of dust particles and wet-scrubbed to dissolve the rhenium oxide. The rhenium-bearing solution is conditioned for ion exchange treatment by the addition of certain chemicals to remove impurities. The solution is clarified, and the rhenium is absorbed on an ion exchange resin. Further hydrometallurgical steps are carried out until a high-purity ammonium perrhenate (NH_4ReO_4) is produced which is converted to metal powder by hydrogen reduction. The metal powder is pressed and sintered into bars which are cold-rolled to form different shapes. Perrhenic acid ($HReO_4$) is obtained by the reaction of rhenium heptoxide with water. The cost of producing rhenium powder or rhenium salts is high. Recent research has developed processes whereby rhenium and molybdenum can be recovered from molybdenite concentrates by hydro-metallurgy.

Properties and uses

Rhenium has become an important industrial metal because of special or unique properties. The metal is highly refractory, having a melting point of 3,100°C, second to that of tungsten, and maintains strength and ductility at high temperatures even after heating above the crystallization temperature. Its density is 21, exceeded only by that of the platinum group metals. Pure rhenium can be cold-worked, but requires high-temperature recrystallization annealing to ensure maximum ductility. It is difficult to work at normal hot-working temperatures because it tends to become brittle. The metal can be welded by tungsten-arc, inert gas techniques; the welds being ductile. Rhenium has good corrosion resistance to halogen acids. Alloyed with tungsten or molybdenum, rhenium improves the ductility and tensile strength of these metals. At room temperature, rhenium has a high-resistivity property which finds application in the rapid initial heating of filaments and heating elements. Stable oxide film on rhenium does not appreciably increase electrical resistance because the oxides are conductive. This property, plus good resistance to wear and arc corrosion, makes the metal ideally suited for electrical contacts.

The major use of rhenium in 1975 was in bimetallic platinum-rhenium catalysts used in reforming units to produce a high-octane gasoline of low-lead and no-lead content.

Rhenium powder is used to produce ductile, high-temperature, tungsten-based alloys which are used in the electronic field. Other applications of rhenium are high-temperature thermocouples, temperature controls, heating elements, electronic devices, flashbulb filaments, heat shields and in research and development work.

Outlook

The development of rhenium as an industrial metal has taken place recently and has not shown any clearly-defined growth pattern. The potential short-term supply is limited to that available from the treatment of byproduct molybdenite concentrates obtained from low-grade porphyry copper ores. The recovery of rhenium from molybdenite concentrates is relatively low, about 50-60 per cent, and research into processes to improve recovery could add to the supply of the metal. Also, any improvement in the recovery of molybdenite concentrates in the processing of porphyry copper ores would increase the available rhenium.

Some of the molybdic oxide producers do not recover the rhenium content of the molybdenite concentrates processed by them because of the costs involved in installing the required equipment. These molybdic oxide operations could be an added source of rhenium.

In the short term the major demand for rhenium will be its application as a bimetallic platinum-rhenium catalyst in the petroleum refining industry, although substitutions of other metals could reduce the demand for rhenium in this application. Success in research projects on new uses for rhenium could increase its consumption. Rhenium metal now available to the market is greater than the demand and stocks are expected to continue to grow. In the United States, stocks in the hands of consumers and producers increased from 9,700 pounds in 1971 to an estimated 28,000 pounds in 1975. Low rhenium reserves could be an important factor in limiting the development of industrial uses for the metal.

Prices

United States

	Perrhenic Acid (Rhenium Content)	U.S. Producer Powder
	(U.S. $ per pound of rhenium)	
January 1 - March 14	600	625
March 15 - August 21	550	575
August 22 - December 31	515	540

Source: *Metals Week.*

Tariffs

Canada — not specifically enumerated in Canadian tariffs.

United States

Item No.		On and After January 1, 1975
		(%)
628.90	Rhenium unwrought, waste and scrap[1]	5
628.95	Rhenium wrought	9

Source: Tariff Schedules of the United States Annotated (1976) T.C. Publication 749.

1 Duty on waste and scrap suspended until June 30, 1978.

Salt

B.W. BOYD

In 1975 total salt production in Canada decreased by 11.5 per cent to 5,329,666 short tons, mainly because of strikes at four locations which caused lost time of over 67,000 man-days. The value of exports declined by $1,668,000 to $5,183,000 and the value of imports rose by $4,962,000 to $9,385,000. For only the second year since 1955 the balance of trade in salt has not been in Canada's favour.

Deposits and occurrences

Salt occurs in solution in seawater, in some spring and lake waters, in many subsurface waters, and in solid form in surface and underground deposits. Although seawaters contain the largest reserve of salt and contribute substantial quantities of solar evaporated salt to the world's annual output, underground bedded and dome deposits supply the largest part of mankind's salt requirements.

In Canada, underground salt deposits have been found in all provinces except British Columbia. They have also been found in the District of Mackenzie, Northwest Territories, and there are underground salt deposits in some of the Arctic islands. Bedded rock salt deposits in southwestern Ontario, Saskatchewan and Alberta, and dome deposits in Nova Scotia are the sources of most of Canada's salt output. In past years, salt has been recovered from brine springs and natural subsurface brines in Nova Scotia, New Brunswick, Ontario, Manitoba, Saskatchewan and Alberta. Salt springs are also common to certain parts of British Columbia.

Production and developments in Canada

Canadian salt production falls into three categories: mined rock salt (3 mines); fine vacuum salt (6 evaporator plants); and salt in brine (4 brining plants) for chemical manufacture. One fine-salt plant was using byproduct salt from a potash-solution mine, and byproduct salt from potash mines was also processed for snow and ice control on roads.

In 1975, shipments of Canadian salt totalled 5,646,670 tons valued at about $59,714,393. This is six per cent less volume and about the same value as recorded in 1974. Production of mined rock salt totalled 3,699,826 tons, about 11.5 per cent less than in 1974. Production of fine vacuum salt totalled 618,138 tons, about 19.0 per cent less than in 1974. The production of salt from brines fell by 5.5 per cent to 1,011,702 tons. No salt was reported recovered in chemical operations in 1974 or 1975. Shipments of all classifications of salt exceeded production as producers drew on stockpiles to help satisfy demand.

Ontario. Thick salt beds underlie much of southwestern Ontario, extending from Amherstburg northeastward to London and Kincardine, bordering on what is known geologically as the Michigan Basin. As many as six salt beds, occurring in the Upper Silurian Salina Formation and at depths from 900 to 2,700 feet, can be identified and traced from drilling records. Maximum bed thickness is 300 feet, with aggregate thickness reaching as much as 700 feet. The beds are relatively flat-lying and undisturbed, permitting easy mining.

In 1975 these beds were worked through two rock salt mines, one at Goderich and one at Ojibway, and through brining operations at Goderich, Sarnia, Windsor and Amherstburg. The Canadian Salt Company Limited's Windsor plant was closed for eight months by a strike by 323 workers. Customers were served by Domtar Chemicals Limited and by Canadian Salt's operations at Pugwash, Nova Scotia and in the prairie provinces. The Sifto Salt division of Domtar Chemicals Limited was hampered by a 170-day strike at its evaporation plant but production at its Goderich mine was held up for only three days by a strike in sympathy for workers at the evaporation plant.

Atlantic region. Salt deposits occur in isolated subbasins of a large sedimentary basin that underlies the northern mainland of Nova Scotia and extends westward under the bordering areas of New Brunswick, northeastward under Cape Breton Island, Prince Edward Island, the Magdalen Islands and southwestern Newfoundland. The salt beds occur within the Mississippian Windsor Group and are generally folded and faulted. The deposits appear to be steeply dipping tabular bodies or domes and brecciated structures of rock salt.

The only salt production in the Atlantic provinces in 1975 was from a rock salt mine and associated evaporator plant at Pugwash, Nova Scotia, and a brining operation at Amherst, Nova Scotia. The mine at Pugwash, owned by The Canadian Salt Company Limited suffered a 26-day strike in January, involving 150 workers.

In New Brunswick, International Minerals & Chemical Corporation (Canada) Limited (IMC) received a letter of intent signed by the province giving

Table 1. Canada, salt production and trade, 1974-75

	1974		1975p	
	(short tons)	($)	(short tons)	($)
Production	6,023,122	. .	5,329,666	. .
Shipments				
By type				
Mined rock salt	4,170,130	37,401,000	3,997,116	33,797,000
Fine vacuum salt	762,919	19,973,000	637,852	22,324,000
Salt content of brines used or shipped	1,070,932	3,245,000	1,011,702	3,593,000
Total	6,003,981	60,619,000	5,646,670	59,714,000
By province				
Ontario	4,456,357	40,169,561	4,147,959	32,259,074
Nova Scotia	863,014	11,179,065	846,500	14,509,494
Saskatchewan	296,309	5,280,625	304,682	7,509,598
Alberta	356,215	3,840,186	317,490	5,286,032
Manitoba	32,086	150,000	30,039	150,195
Total	6,003,981	60,619,437	5,646,670	59,714,393
Imports				
Total salt and brine				
United States	481,296	3,358,000	855,477	7,930,000
Mexico	304,272	857,000	181,928	827,000
Bahamas	16,162	116,000	81,309	486,000
Spain	—	—	6,524	72,000
United Kingdom	—	—	3,661	23,000
West Germany	462	13,000	110	23,000
Norway	635	35,000	238	12,000
Switzerland	73	6,000	61	12,000
Other countries	9,033	38,000	4	. . .
Total	811,933	4,423,000	1,129,312	9,385,000
Exports				
United States	. .	6,683,000	. .	5,128,000
St. Pierre-Miquelon	. .	2,000	. .	15,000
Bermuda	. .	10,000	. .	9,000
Guyana	. .	5,000	. .	7,000
Leeward and Windward Islands	. .	9,000	. .	6,000
United Kingdom	. .	102,000	. .	4,000
Jamaica	. .	5,000	. .	3,000
Cuba	. .	3,000	. .	3,000
Other countries	. .	32,000	. .	8,000
Total	. .	6,851,000	. .	5,183,000

Source: Statistics Canada.
p Preliminary; . . Not available; — Nil; . . . Less than $1,000.

Table 2. Canada, salt shipments, 1966-75

	Shipments					
	Mined Rock	Fine Vacuum	In Brine and Recovered in Chemical Operations	Total	Imports	Exports
			(short tons)			($)
1966	2,180,671	571,497	1,376,654	4,128,822	509,548	3,588,000
1967	3,023,397	554,337	1,417,894	4,995,628	567,012	5,926,000
1968	3,230,305	553,280	1,080,739	4,864,324	644,153	5,921,000
1969	3,007,256	557,028	1,093,481	4,657,765	695,638	5,107,000
1970	3,607,336	609,252	1,142,308	5,358,896	618,021	7,430,000
1971	4,045,894	625,552	870,458	5,541,904	922,013	7,029,000
1972	3,901,099	638,520	877,306	5,416,925	1,024,255[r]	4,988,000[r]
1973	3,788,040	746,274	1,030,313	5,564,627	928,075	6,051,000
1974	4,170,130	762,919	1,070,932	6,003,981	811,933	6,851,000
1975[p]	3,997,116	637,852	1,011,702	5,683,670	1,129,312	5,183,000

Source: Statistics Canada.
[p] Preliminary; [r] Revised.

IMC rights for exploration and development of potash and salt on a prospect near Salt Springs. By year-end IMC had drilled two holes which intersected potash and salt. Drilling will continue in 1976.

In Quebec, the Quebec Mining Exploration Company (SOQUEM) continued exploration for salt on the Magdalen Islands. Development of a mine hinges on construction of port facilities by the federal government.

Prairie Provinces. Salt beds underlie a broad belt of the Prairie Provinces extending from the extreme southwestern corner of Manitoba northwestward across Saskatchewan and into the north-central part of Alberta. Most of the salt deposits occur within the Prairie Evaporite Formation, which constitutes the upper part of the Middle Devonian, Elk Point Group, with thinner beds of salt occurring in Upper Devonian rocks. Depths range from 600 feet at Fort McMurray, Alberta, to 3,000 feet in eastern Alberta, central Saskatchewan and southwestern Manitoba, and to 6,000 feet around Edmonton, Alberta, and in southern Saskatchewan. Cumulative thicknesses reach a maximum of 1,300 feet in east-central Alberta. The beds lie relatively flat and undisturbed. The same rock sequence contains a number of potash beds that are being exploited in Saskatchewan.

Salt was produced from these deposits at four locations in the Prairie Provinces in 1975: Saskatoon and Unity, Saskatchewan; and Lindbergh and Fort Saskatchewan, Alberta. In addition, naturally occurring subsurface salt brines in Manitoba were used for caustic soda and chlorine manufacture at Brandon. Fine salt was also produced from byproduct brines from a potash solution mine at Belle Plaine, Saskatchewan. International Minerals & Chemical Corporation (Canada) Limited, at Esterhazy, Saskatchewan, supplied a significant quantity of waste salt from potash mining for snow and ice control on highways. The Domtar Chemicals Limited plant at Unity suffered a four-month strike during the summer.

Recovery method

Canadian producers employ three different techniques in the recovery of salt and/or brine from depth, the method employed depending upon the nature of the deposit and the type of salt in demand. Conventional underground mining methods are used to mine rock salt deposits that are relatively shallow, and are located in areas near large markets that do not specify a high-purity product.

Brining methods too are used to recover salt from subsurface deposits, usually from depths greater than mining depths. Brine can be evaporated to produce high-purity fine vacuum salt or it can be used directly in the manufacture of chemicals. Salt is similarly recovered from natural subsurface brines.

The third technique is to recover salt as a coproduct of potash mining, a practice quite common in Europe. In Canada, the only commercial application of this technique is at a solution-type potash mine, where production methods permit the recovery of a good-quality salt brine. The other potash producers generally regard the waste salt as unmarketable, although some shipments have been made for snow and ice control.

A fourth method (not used in Canada) is solar evaporation of sea or salty lake waters, a process commonly used in warm, acid climates.

Table 3. Canada, summary of salt producing and brining operations, 1973

Company	Location	Initial Production	Remarks
Nova Scotia			
The Canadian Salt Company Limited	Pugwash	1959	Rock salt mining at a depth of 630 feet.
	Pugwash	1962	Dissolving rock salt fines for vacuum pan evaporation.
Domtar Chemicals Limited	Amherst	1947	Brining for vacuum pan evaporation.
Ontario			
Allied Chemical Canada, Ltd.	Amherstberg	1919	Brining to produce soda ash.
The Canadian Salt Company Limited	Ojibway	1955	Rock salt mining at a depth of 980 feet.
The Canadian Salt Company Limited	Windsor	1892	Brining, vacuum pan evaporation and fusion.
Dow Chemical of Canada, Limited	Sarnia	1950	Brining to produce caustic soda and chlorine.
Domtar Chemicals Limited	Goderich	1959	Rock salt mining at a depth of 1,760 feet.
	Goderich	1880	Brining for vacuum pan evaporation.
Prairie Provinces			
Hooker Chemical Canada Ltd.	Brandon, Man.	1968	Pumping natural brines to produce caustic soda and chlorine. Operation purchased from Dryden Chemicals Limited in 1974.
Northern Industrial Chemicals Ltd.[1]	Saskatoon, Sask.	1968	Brining to produce caustic soda and chlorine.
Domtar Chemicals Limited	Unity, Sask.	1949	Brining, vacuum pan evaporation and fusion.
The Canadian Salt Company Limited	Lindbergh, Alta.	1968	Brining, vacuum pan evaporation and fusion.

Table 3. (concl'd)

Company	Location	Initial Production	Remarks
Prairie Provinces (concl'd)			
Dow Chemical of Canada, Limited	Fort Saskatchewan, Alta.	1968	Brining to produce caustic soda and chlorine.
The Canadian Salt Company Limited	Belle Plaine, Sask.	1969	Producing fine salt from byproduct brine from potash mine.
International Minerals & Chemical Corporation (Canada) Limited	Esterhazy, Sask.	1962	Byproduct salt from potash mine for use in snow and ice control.

Source: Mineral Development Sector, Department of Energy, Mines and Resources, Ottawa.
[1]Managed by Canadian Industries Limited.

Rock salt mining

Access to rock salt deposits for conventional mining is through vertical shafts, normally 16 feet in diameter, serving the mining zone at depths of 630 to 1,760 feet. Mining is normally by the room-and-pillar method, the dimensions depending on the depth and thickness of the salt deposit. Rooms vary from 30 to 60 feet in width and from 18 to 50 feet in height, and pillars vary from about 60 to 200 feet square. Extraction ranges from 40 to 60 per cent. The mining operation consists of undercutting, drilling blasting, loading and primary crushing. Underground haulage is by shuttle cars, trucks and conveyor belts. Milling involves crushing, screening and sizing; at one mine the milling is done underground. The products, ranging in size from about one half inch to a fine powder, normally have a purity of 96 per cent or better. Most of the gypsum, anhydrite and limestone impurities are removed during crushing and screening. Small amounts of the coarser salt fractions are further beneficiated by use of electronic sorters.

Most of the rock salt mined in Canada is shipped in bulk by water, rail and road, much of it being used for snow and ice control.

Brining and vacuum pan evaporation

Underground brining is accomplished by injecting water into a salt deposit to dissolve the salt, then pumping the resulting saturated salt solution to the surface. Water injection and brine recovery can be done through a single borehole, with casing and tubing; or through a series of two or more cased wells. A brine field normally has from 2 to 20 wells, depending on the quantity of brine needed for the surface operation. Depths of the brine fields in Canada range from 1,100 to 6,500 feet. Saturated salt brine contains 26 per cent NaCl, which amounts to about three pounds of salt per gallon of fluid. At the surface the brine is either evaporated to produce fine vacuum salt, or used directly in the manufacture of chemicals.

Canadian producers use a vacuum-pan process to evaporate the brine and produce fine salt. The brine is

Table 4. World salt production 1973-75

	1973^p	1974^p	1975^e
	('000 short tons)		
United States	43,911	46,536	43,418
People's Republic of China	$20,000^e$	19,800	20,700
U.S.S.R.	13,400	13,780	14,000
United Kingdom	$10,200^e$	9,262	10,000
West Germany	$10,427^e$	8,825	9,000
India	7,721	6,990	8,000
France	6,044	6,609	6,500
Italy	4,886	5,736	5,700
Canada	5,565	6,023	5,330
Australia	$4,400^e$	5,290	5,400
Mexico	$5,100^e$	4,740	5,300
Poland	3,394	3,632	3,600
Other countries	30,477	32,030	32,000
	165,525	169,234	169,303

Sources: U.S. Bureau of Mines *Minerals Yearbook* Preprint 1973 and U.S. Bureau of Mines *Commodity Data Summaries* January 1976; for Canada, Statistics Canada.
^{p}Preliminary; ^{e}Estimated.

purified to remove gypsum and other impurities and fed into a series of three or four large cylindrical steel vessels under vacuum for triple-or quadruple-effect evaporation. The salt crystallizes and is removed as a slurry, washed, filtered and dried. Product purity is generally 99.5 per cent or better.

Final processing involves screening, the introduction of additives, compression into blocks, briquettes and tablets, or compaction, recrushing and packaging to prepare as many as 100 different salt products. In some cases, small quantities are melted at a temperature of about 1,500°F and allowed to cool. This produces a fused salt, which is particularly suitable for use in water softeners.

Canadian consumption and trade

Salt is marketed in at least 100 different forms, packages and containers and its direct and indirect uses number in the thousands. The largest single market for salt in Canada is for snow and ice control on highways and city streets. By comparison with other uses, this market is new, having expanded in Canada from less than 100,000 tons in 1954 to an estimated 2.54 million tons in 1975.

The next-largest consumer of salt is the industrial chemical industry, particularly the manufacture of caustic soda (sodium hydroxide) and chlorine. Salt for four caustic soda and chlorine plants is obtained from on-site brining and natural brines; others use mined rock salt or imported solar salt. Other industrial chemicals that require significant quantities of salt in the manufacturing process include sodium carbonate (soda ash), sodium chlorate, sodium bicarbonate, sodium chlorite and sodium hypochlorite.

The pattern of Canada's salt trade has changed considerably in the past few years. Because of its low unit value and availability in most key market areas, salt is seldom hauled long distances, except in the case of seaborne and intercoastal shipments where greater mileage entails little additional cost.

Canadian exports of salt decreased in 1975, coincident with reduced salt consumption by the chemical industry in the United States. In 1975, the value of exports of salt to the United States fell by $1,555,000 from the value of 1974, a turnaround from the $735, 000 increase in sales experienced a year earlier.

Canadian imports of salt increased by 39 per cent, with imports from the United States nearly double the

Table 5. Canada, available data on salt consumption, 1972-75

	1972	1973	1974	1975[e]
	(short tons)			
Industrial chemicals	1,693,150	1,250,481	1,570,798	1,643,000
Snow and Ice control[1]	2,204,485	2,222,541	2,445,655	2,537,015
Slaughtering and meat packing	41,049	40,912	37,851	44,000
Food processing				
Fish products	16,428	17,932	17,294	17,000
Bakeries	14,739	15,632	19,330	16,000
Miscellaneous food preparation	18,542	19,997	21,252	20,000
Fruit and Vegetable preparation	20,110	22,236	21,861	20,000
Other food preparation	2,187	2,129	2,127	4,000
Breweries	989	747	464	850
Dairy factories and process cheese	9,441	8,304	9,294	8,000
Leather tanneries	13,552	9,346	11,832	8,000
Soaps and cleaning preparations	2,252	5,173	2,785	4,000
Dyeing and finishing textiles	1,992	1,596	1,590	4,000
Artificial ice	880	1,000	1,000	1,000
Pulp and paper mills	32,804	63,990	34,876	56,000
Grain mills[2]	56,210	61,654	60,990	56,000
Fishing industry[e]	90,000	90,000	96,000	91,000

Sources: Statistics Canada; Salt Institute.
[e] Estimated by Mineral Development Sector, Department of Energy, Mines and Resources, Ottawa.
[1] Fiscal year ending June 30. [2] Includes feed and farm stock salt in block and loose forms.

level of 1974. Imports from Mexico were lower than in 1974, as the price of Mexican salt increased from an average of $2.82 a ton to $4.55 a ton. Imports of salt to Canada in 1975 were from the United States (76 per cent); Mexico (16 per cent); and Bahamas (7 per cent).

Outlook

In 1975 the average price of salt imported by Canada increased to $8.31 a ton from $5.45 a ton in 1974. The Mexican government has been attempting to increase the price for its sales of salt to Japan to $7.00 a ton from about $5.00 a ton. The price of salt from Mexico will probably increase proportionately for Canadian purchasers, and imports from Mexico will probably decrease. If the price of imported salt continues to rise at the rate of 30 to 50 per cent as it did in 1975, shipment of byproduct salt from potash mines in Saskatchewan to the markets in Vancouver will become economic and imports of salt into Canada will fall significantly.

Tariffs

Canada

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
			(¢ per 100 lb)		
92501-1	Common salt (including rock salt)				
	On and after Jan. 1, 1971	free	1/2	5	free
	On and after Jan. 1, 1972	free	free	5	free
92501-2	Salt for use of the sea or gulf fisheries	free	free	free	free
92501-3	Table salt made by the admixture of other ingredients when containing not less than 90 per cent of pure salt	(%)	(%)	(%)	(%)
	On and after Jan. 1, 1971	5	6	15	3
	On and after Jan. 1, 1972	5	5	15	3
92501-4	Salt liquors and sea water	free	free	free	free

United States

Item No.		On and After Jan. 1, 1972
420.92	Salt in brine	5%
		(¢ per 100 lb)
420.94	Salt in bulk	0.8
420.96	Salt, other	free

Sources: For Canada, The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa, Canada. For United States, Tariff Schedules of the United States Annotated (1976) TC Publication 749.

Sand and Gravel

D.H. STONEHOUSE

Unconsolidated granular mineral material produced by the natural disintegration of rock under weathering and erosion processes is termed either "sand" or "gravel". The terms relate to grain size rather than to composition. Sand is defined very generally as passing a 3/8-inch sieve, almost all passing a No. 4 (0.187-inch) sieve, and almost all remaining on a No. 200 (0.003-inch) sieve. Gravel is that granular material remaining on a No. 4 sieve — the cut-off between commercial sand and gravel. Material finer than 200-mesh is referred to as silt or clay, depending on the particle size.

Commercial sand and gravel deposits are generally classified into one of four categories according to origin or method of deposition. Deposits composed of sand and gravel that had been carried by rivers and streams are referred to as fluvial deposits. They exhibit limited size gradation, and the distribution of size ranges and shapes can vary greatly, depending on whether the streams had been meandering, fast-flowing, narrow or shallow. Glacial deposits were distributed from massive ice sheets over large areas of Canada and the United States as well as other countries. They consist of rock particles of various types, shapes and sizes and display little sorting or gradation. Marine and lake deposits are usually of hard, tough material, well segregated and well worn to rounded shapes. Unstratified mixtures of sand and gravel, covering the complete size range and occurring on top of the parent rock, are termed residual deposits. These are not usually of commercial importance because of the large amount of softer clays associated with the mass.

The Canadian industry

Activity in the construction industry in Canada, particularly the heavy or engineering construction segment, determines to a great extent the amount of aggregate produced and used. The construction industry is often the first to be influenced by changes in the economic climate and, as suppliers of raw materials to such a volatile industry, the producers of sand and gravel and other aggregates must be capable of adjusting to "go" and "no go" situations, as well as to surges in demand caused by regional and seasonal construction programs.

Sand and gravel deposits are widespread throughout Canada, and large producers have established "permanent" plants as close to major consuming centres as possible. Urban expansion has greatly increased demand for sand and gravel in support of major construction. Paradoxically, urban spread has not only tended to overrun operating pits and quarries, but has extended, at times, to areas containing mineral deposits, thereby precluding the use of these resources. Further complications have arisen in recent years as society has become increasingly aware of environmental problems and of the need for planned land utilization. Municipal and regional zoning must be designed to determine and regulate the optimum utilization of land, but must not be designed to provide less than optimum resource utilization. Industry must locate its plants so as to minimize any adverse effects on the environment from their operations. Also, provision must be made for rehabilitation of pit and quarry sites in order to ensure the best sequential land use. The frequency with which small quarries and pits materialize to supply short-lived, local demands, leaving unsightly properties, has prompted action by municipal and provincial governments to control or to prohibit such activity.

Ideally, the exploitation of sand, gravel and stone deposits should be done as part of the total land use planning package, such that excavations are designed to conform with a master plan of development and even to create new land forms. Ontario seems to be leading other provinces in enacting legislation to control pit and quarry licensing, operation and rehabilitation; and its new laws are typical of what can be expected in other provinces. Ontario regulations apply to operations in designated areas and to rehabilitation of depleted sites. Controls and zoning can significantly reduce reserves of these building materials.

Inventories indicating the potential available reserves of sand, gravel and stone should be prerequisite to legislation regulating land use. Surveys to locate such resources are being carried out in many provinces in order to optimize their use and to choose the best possible distribution routes to consuming centres.

In addition to large aggregate operations usually associated with some other phase of the construction industry such as a ready-mix plant or an asphalt plant, there are many smaller, privately owned producers serving small, localized markets. These are often operated on a seasonal or part-time basis. Many larger operations are short-term, intermittently serving as a supply arm of a heavy construction company, and providing material for a given project. Provincial departments of highways operate regional or divisional quarries to supply roadbed material for new and repair work. Exploitation by such a large number of widely diversified groups not only makes control difficult, it also provides great obstacles to the collection of accurate total production data.

Table 1. Canada, construction spending by provinces, 1974-76

	1974[1]	1975[2]	1976[3]
	(millions of dollars)		
Newfoundland	519.8	548.8	652.1
Prince Edward Island	84.3	82.3	72.2
Nova Scotia	586.6	630.4	758.1
New Brunswick	649.7	741.9	736.8
Quebec	4,747.3	5,966.8	6,444.7
Ontario	7,087.7	7,480.9	8,156.7
Manitoba	807.8	858.7	974.3
Saskatchewan	681.4	884.0	1,100.6
Alberta	2,506.3	3,331.8	4,262.4
British Columbia	2,735.8	3,007.2	3,297.7
Yukon and Northwest Territories	364.4	361.5	354.2
Canada	20,771.1	23,894.3	26,809.8

Source: Statistics Canada.
[1]Final [2]Preliminary; [3]Forecast.

Although producers' shipments as recorded by Statistics Canada (Catalogue 26-215) reflect the total amounts of sand and gravel recovered by all producers regardless of statistical classification, only about 150 "establishments" are listed, showing a total employment of less than 2,000 persons. More detailed data from individual provincial government departments such as highways, municipal affairs, natural resources, lands and forests are required to reveal the total number of active pit and quarry operations.

Materials competitive with sand and gravel include crushed stone and the lightweight aggregates, depending on the application considered. It has been estimated that total aggregate consumption in some Canadian urban centres could reach 18 tons per capita by 1980. Estimates have indicated that available sand and gravel supplies in some regions will be depleted by the 1990s. This could make outlying deposits not only attractive but necessary, and could also encourage development of underwater deposits. Marine aggregates now account for about 12 per cent of total sand and gravel production in the United Kingdom, the world's largest producer from such resources. It is not completely impossible that areas of concentrated population, such as the eastern seaboard of the United States where reserves of aggregate are already becoming depleted, will have to import their requirements, perhaps from offshore by boat or barge. Large tonnages of crushed limestone are exported annually from Canada's west coast quarries, particularly from Texada and Aristazabal islands, for cement, lime and aggregate use in Oregon and Washington.

The main uses for sand and gravel are: as fill, granular base- and finish-course material for highway construction, coarse and fine aggregates in concrete manufacture; coarse aggregate in asphalt production and fine aggregate in mortar and concrete blocks. Specifications vary greatly, depending on the intended use, and many tests are required to determine the

Table 2. Canada, production (shipments) sand and gravel by provinces, 1973-75

	1973		1974		1975[p]	
	('000 st)	($000)	('000 st)	($000)	('000 st)	($000)
Newfoundland	6,466	8,371	6,772	8,728	5,900	7,800
Prince Edward Island	1,632	1,680	974	1,454	960	1,540
Nova Scotia	11,348	12,524	11,578	16,169	8,900	12,500
New Brunswick	9,553	10,550	8,251	5,558	6,500	4,500
Quebec	51,543	32,486	66,412	48,223	43,000	31,500
Ontario	80,568	74,408	79,985	85,518	76,200	92,000
Manitoba	12,782	14,484	19,039	22,168	18,400	24,800
Saskatchewan	6,836	5,203	11,840	9,736	11,500	9,800
Alberta	18,607	17,852	24,703	31,166	23,400	40,300
British Columbia	34,126	35,879	34,225	35,265	30,200	35,600
Canada	233,461	213,437	263,779	263,985	224,960	260,340

Source: Statistics Canada.
[p]Preliminary.

Table 3. Production (shipments) sand and gravel, by uses, by areas, 1973-74

		Atlantic Provinces	Quebec	Ontario	Western Provinces	Canada
		('000 short tons)				
Roads	1973	22,979	39,013	42,322	36,356	140,670
	1974	22,034	47,255	42,457	42,913	154,659
Concrete aggregate	1973	1,479	5,299	17,242	13,928	37,948
	1974	1,872	6,110	18,233	16,539	42,754
Asphalt aggregate	1973	2,461	2,185	4,480	5,066	14,192
	1974	2,335	2,330	4,437	7,038	16,140
Railroad ballast	1973	270	696	259	3,654	4,879
	1974	208	316	278	4,019	4,821
Mortar sand	1973	96	155	2,054	829	3,134
	1974	65	83	2,713	829	3,690
Backfill for mines	1973	84	175	846	326	1,431
	1974	138	127	979	3	1,247
Other fill	1973	1,461	2,330	12,826	11,902	28,519
	1974	912	9,994	10,425	16,338	37,669
Other uses	1973	169	1,690	539	290	2,688
	1974	12	197	463	2,127	2,799
Total sand and gravel	1973	28,999	51,543	80,568	72,351	233,461
	1974	27,576	66,412	79,985	89,806	263,779

Source: Statistics Canada, with breakdown by Statistics Section, Mineral Development Sector.

Table 4. Canada, exports and imports of sand and gravel, 1973-75

	1973		1974		1975^p	
	(short tons)	($)	(short tons)	($)	(short tons)	($)
Exports						
Sand and gravel						
United States	880,350	937,000	393,121	775,000	152,559	352,000
Peru	—	—	—	—	29	10,000
Australia	—	—	—	—	18	1,000
Other countries	674	16,000	503	6,000	11	2,000
Total	881,024	953,000	393,624	781,000	152,617	365,000
Imports						
Sand and gravel, not elsewhere stated						
United States	1,136,055	1,280,000	1,733,489	2,465,000	2,104,664	3,530,000
West Germany	—	—	341	20,000	633	10,000
Other countries	211	2,000	—	—	1	. . .
Total	1,136,266	1,282,000	1,733,830	2,485,000	2,105,298	3,540,000

Source: Statistics Canada.
— Nil; . . . Less than one thousand dollars; ^{p}Preliminary.

acceptability of aggregates for certain applications. Particle size distribution of aggregates, as assessed by grading tests or sieve analysis, affects the uniformity and workability of a concrete mix as well as the strength of the concrete, the density and strength of an asphalt mix, and the durability, strength and stability of the compacted mass when aggregates are used as fill or base-course material. Of importance also are tests to determine the presence of organic impurities or other deleterious material, the resistance of the aggregate to abrasion and to freeze-thaw cycles, the effects of thermal expansion, absorption, porosity, reactivity with associated materials and surface texture.

The use of sand and gravel as backfill in mines continues, along with increasing use of cement and mill tailings for this purpose. Abrasive sands, glass sand, foundry sands and filter sands are also produced.

Even the common products such as sand and gravel require a sales and distribution effort which depends upon forecast data supplied by monitoring relevant indicators. One such indicator is the number of regional housing starts which, in turn, can be projected to determine future needs for roads, driveways, shopping centres and schools. Heavy construction awards can be used to provide an estimate of the quantity of aggregate required for given projects, over given periods of time.

There is no standard price for sand and gravel. Prices are determined regionally, or even locally, by production and transportation costs, by the degree of processing required for a given end use and by the quantity of material required for a particular project. Increased land values, reduction of reserves and added rehabilitation expenditures should result in higher prices.

Sand and gravel must be quarried, screened, washed, stockpiled and transported in large volume to compensate for the relatively low unit value received. Transportation and handling often double the plant cost, making it necessary to utilize close-in reserves and influencing the scope of exploration for new deposits. The need for an inventory of aggregate materials surrounding regions of large population growth cannot be emphasized too strongly.

Unit trains, or more precisely, "hook and haul" trains, have been used to transport aggregate into the Toronto area in minimum loads of 4,000 tons at negotiated freight rates. The wide physical distribution of consumers within the area being served causes difficulties with such a system as further handling and transporting is required.

Table 5. Canada, production (shipments) sand and gravel, by uses, 1973-74

	1973	1974
	(000 short tons)	
Roads – construction, maintenance, ice control	140,670	154,659
Concrete aggregate	37,948	42,754
Asphalt aggregate	14,192	16,140
Railroad ballast	4,879	4,821
Mortar sand	3,134	3,690
Backfill for mines	1,431	1,247
Other fill	28,519	37,669
Other uses	2,688	2,799
Total sand and gravel	233,461	263,779
$000	213,437	263,985

Source: Statistics Canada with breakdown by Statistics Section, Mineral Development Sector.

Table 6. Canada, sand and gravel production (shipments) and trade, 1965-75

	Production	Imports	Exports
		(short tons)	
1965	205,260,264	570,977	687,941
1966	217,271,189	566,800	700,255
1967	215,212,700	757,603	601,419
1968	205,234,509	683,490	496,525
1969	201,581,498	859,898	457,918
1970	202,656,000	502,739	1,240,192
1971	213,291,000	675,275	774,726
1972	225,194,000	1,067,633	697,177
1973	233,461,479^r	1,136,266	881,024
1974	263,778,623^r	1,733,830	393,624
1975^p	224,960,000	2,105,298	152,617

Source: Statistics Canada.
^{p}Preliminary; ^{r}Revised.

Outlook

On average, total aggregate consumption will rise in line with population increases, housing requirements and construction in general. Sand and gravel consumption will continue in competition with crushed stone and, in some applications, with lightweight aggregates. New resource reserves must be located, assessed and made part of any community development planning or regional zoning, with optimum land and resource utilization in mind. In the search for new sources of sand and gravel some countries are turning to their sea beds. The use of huge pumps and specially equipped ships to draw gravel from the sea floor and deposit it in attendant barges is already common practice in Britain. Such methods of obtaining aggregates can have far-reaching environmental effects.

Prices for graded, washed and crushed gravel and sand will show slow but steady increase, based on greater property costs, more sophisticated operating techniques and equipment, pollution and environmental considerations, and higher labour costs.

Selenium and Tellurium

J.J. HOGAN

SELENIUM

Selenium is a rare earth metal which occurs sparsely disseminated throughout the earth's crust, where it is the 69th element in order of abundance. Selenium was first discovered in 1817 by the Swedish chemist Berzelius. Selenium occurs in minerals associated with copper, lead and iron sulphides. Commercial production is from electrolytic copper refinery slimes and from flue dusts from copper and lead smelters. Therefore, the quantity of selenium produced in any particular year is dependent upon the level of production in the world primary copper-refining industry. Countries producing selenium include the United States, Canada, Japan, the U.S.S.R., Belgium and Luxembourg, Sweden, Mexico, Yugoslavia, Finland, Peru, Australia and Zambia. A significant amount of selenium is also produced each year from secondary sources.

Production of selenium in all forms, from Canadian copper refineries plus refined selenium from domestic primary materials, was 670,000 pounds in 1975 valued at $12,330,000, compared with 599,950 pounds valued at $9,449,212 in 1974. Canada was the largest producer of selenium in the noncommunist world in 1975, followed closely by Japan. The United States is also a major producer.

Domestic consumption amounted to 21,900 pounds in 1975 compared with 30,479 pounds in 1974 and 22,435 pounds in 1973. The major user of selenium in Canada has been the glass industry, which accounted for 75 per cent of the total consumption in 1975.

Table 1 gives details of Canadian selenium production, exports and consumption in 1975 and 1974. With the exception of Quebec, which reported a substantial increase, production from the other provinces and from imported material and secondary sources showed only small variations from 1974. An increase in the average price of selenium for the year and higher production were responsible for the 30 per cent increase in the value of selenium production in 1975.

As shown in Tables 1 and 2 the bulk of Canada's production of selenium is exported. The quantity of selenium exported each year varies in a wide range and often differs from refined production. The United States is Canada's major market, followed by the United Kingdom. These two countries purchased almost 99 per cent of Canada's exports in 1975.

Total primary production of selenium in the United States in 1975 was estimated at 360,000 pounds, 74 per cent below 1974 production and the lowest level since 1946. The sharp drop in production was attributable to the closing of a major refinery and reduced slime production from the refining of domestic copper ores because of general depressed world economic conditions. The down-trend in the business cycle also lowered the demand for selenium and resulted in a build-up of stocks held by the United States producers.

Canadian Copper Refiners Limited at Montreal East, Quebec, operates Canada's largest selenium recovery plant. The company's refinery treats anode copper from the Noranda smelter of Noranda Mines Limited, the Murdochville smelter of Gaspé Copper Mines, Limited, both in Quebec; and blister and anode copper from the smelter of Hudson Bay Mining and Smelting Co., Limited at Flin Flon, Manitoba. The selenium plant can produce commercial-grade metal (99.5 per cent Se), high-purity metal (99.99 per cent Se) and a variety of metallic and selenium compounds. Annual capacity is 500,000 pounds of selenium in metal and salts.

The 180,000 pound-a-year selenium recovery plant of The International Nickel Company of Canada, Limited (Inco) at Copper Cliff, Ontario, treats tankhouse slimes from the company's Copper Cliff copper refinery and its Port Colborne, Ontario, nickel refinery. The marketable product is minus 200 mesh selenium powder (99.5 per cent Se).

Consumption and uses

Selenium is used in the manufacture of glass, steel, electronic components, explosives, animal and poultry feeds, fungicides and pigments, and in xerography.

Selenium metal is marketed in two grades; commercial, with a minimum content of 99.5 per cent Se; and high purity, with a minimum content of 99.99 per cent Se. Other forms in which selenium is available include ferroselenium, nickel selenium, selenium dioxide, barium selenite, sodium selenate, sodium

Table 1. Canada, selenium production, exports and consumption 1974-75

	1974		1975ᵖ	
	(pounds)	($)	(pounds)	($)
Production				
All forms[1]				
Ontario	128,504	2,023,938	106,000	1,950,000
Manitoba	85,600	1,348,200	89,000	1,644,000
Quebec	353,256	5,563,782	440,000	8,096,000
Saskatchewan	32,590	513,292	35,000	640,000
Total	599,950	9,449,212	670,000	12,330,000
Refined[2]	736,233	. .	754,845	. .
Exports (metal)				
United States	607,100	10,877,000	287,000	7,110,000
United Kingdom	258,800	4,177,000	187,500	3,440,000
Brazil	10,200	124,000	2,200	140,000
Jamaica	—	—	1,000	32,000
Colombia	1,700	9,000	1,100	31,000
Japan	21,300	414,000	1,000	23,000
Argentina	14,000	209,000	300	10,000
Other countries	14,400	216,000	500	5,000
Total	927,500	16,026,000	480,600	10,792,000
Consumption[3] (selenium content)	30,479	. .	21,900	. .

Source: Statistics Canada.
[1]Recoverable selenium content of blister copper treated at domestic refineries plus refined selenium from domestic primary materials. [2]Refinery output from all sources, including imported materials and secondary sources. [3]Available data, consumption of selenium products (metal, metal powder, oxide), selenium content, as reported by consumers.
ᵖPreliminary; . . Not available; — Nil.

selenite and zinc selenite. Consumption by industrial sectors in the United States in 1975 was estimated by the United States Bureau of Mines (USBM) to have been: electronic components, 45 per cent; ceramics and glass, 34 per cent; chemicals, 13 per cent and other uses, 8 per cent.

An important use of selenium in the electrical field is in the manufacturing of rectifiers used in electroplating, welding, battery charging and other similar applications. Selenium is used in specialty transformers varying in size from a fraction of a watt to 500 kilowatts. Xerography (electrostatic printing), a dry photocopying or photographing process, uses a large quantity of selenium.

The glassmaking industry is one of the major consumers of selenium. Small quantities added to the glass batch neutralize the greenish tinge imparted to glass by iron impurities in the sand. Selenium is meeting with some competition from cerium in this application. The brilliant ruby-red glass used in traffic and other signal lenses, automotive taillights, marine equipment, infrared equipment and decorative tableware is produced by adding larger quantities of selenium to the glass batch. An increasing amount of selenium is used in tinted "black" glass which is used as the outer facing of many highrise office buildings.

Selenium has wide application in the chemical industry, the most important being the manufacture of the orange-red-maroon cadmium sulphoselenide pigments. They have considerable light stability, maintain their brilliance, and are resistant to heat and chemical action. Their most important application is in the expanding high-temperature, cured-plastic industry, but they are also used to colour ceramics, paints, enamels and inks.

In proportions ranging from 0.2 to 0.35 per cent, selenium imparts improved machinability to stainless steel without affecting its corrosion-resistance properties, and in lesser amounts improves the forging characteristics of steel. Small quantities of iron selenide, from 0.01 to 0.05 per cent, are used as an additive in steel casting to prevent pinhole porosity.

Finely ground metallic selenium and selenium diethyldithiocarbamate (selenac) are used in natural

Table 2. Canada, selenium production, exports and consumption, 1966-1975

	Production		Exports	
	All Forms[1]	Refined[2]	Metals[3]	Consumption[4]
	(pounds)			
1966	575,482	546,085	588,100	20,533
1967	724,573	754,360	539,400	21,017
1968	635,510	620,033	787,100	21,440
1969	599,415	820,277	872,300	15,572
1970	663,336	854,452	686,100	15,730
1971	718,440	885,931	571,500	15,686
1972	582,060	720,392	508,300	20,677
1973	521,110	580,537	823,100	22,435
1974	599,950	736,233	927,500	30,479
1975[p]	670,000	754,845	480,600	21,900

Source: Statistics Canada.
[1]Recoverable selenium content of blister copper treated at domestic refineries, plus refined selenium from domestic primary material. [2]Refinery output from all sources, including imported material and secondary sources. [3]Exports of selenium metal, metal powder, shot, etc. [4]Consumption (selenium content), as reported by consumers.
[p]Preliminary.

Table 3. Noncommunist world production of selenium, 1973-75

	1973	1974	1975[e]
	(pounds)		
Canada	521,000	600,000	670,000
Japan	756,000	800,000	650,000
United States	796,000	644,000	360,000
Sweden	120,000	120,000	110,000
Belgium and Luxembourg	65,000	123,000	100,000
Other countries	308,000	363,000	300,000
Total	2,258,000	2,650,000	2,190,000

Sources: For Canada, Statistics Canada. For other countries, Preprint from the U.S. Bureau of Mines *Minerals Yearbook 1973* and U.S. Bureau of Mines Commodity Data Summaries, January 1976.
[e]Estimated.

and synthetic rubber to increase the rate of vulcanization and to improve the aging and mechanical properties of sulphurless and low-sulphur rubber. Selenac is used as an accelerator in butyl rubber.

Selenium is used in the organic chemical and pharmaceutical industries, in the manufacture of cortisone and nicotine acids, in the preparation of various proprietary medicines for the control of dermatitis in human beings and animals, and in the control of certain diseases in animals and poultry. It is known that selenium is an essential element for normal physical development and prevents white muscle disease in livestock and poultry. Growing attention within this field could result in a large new market for selenium as a feed supplement. In the United States, the Food and Drug Administration has proposed that selenium be added to poultry and swine feed. However, selenium is highly toxic to both livestock and human beings if consumed in excessive quantities.

Table 4. Canada, industrial use of selenium, 1973-75

	1973	1974	1975[p]
	(pounds of contained selenium)		
By end use			
Glass	18,873	22,241	16,359
Other[1]	3,562	8,238	5,541
Total	22,435	30,479	21,900

Source: Statistics Canada Consumers' Reports.
[1]Steel, pharmaceuticals.

A small amount of selenium is used in the manufacture of delay-action blasting caps.

Interest has been revived in the use of selenium in the photogalvanic cell, which converts light energy to electrical energy, as new sources of energy are sought to offset fuel and energy shortages. Also, with respect to the energy situation, an increased demand for selenium-tinted windows, which have a lower heat conductivity than conventional glass, is expected.

Outlook

Selenium production is primarily a byproduct of copper refining, but the relationship is trending towards a lower proportion of selenium output as existing selenium-rich copper reserves are exhausted. An increasing amount of copper production is being derived from selenium-poor ores. Furthermore, environmental standards are leading to technical changes in copper extraction processes that may result in lower selenium recoveries unless a new technology is developed to extract it.

It is likely that Canadian production of selenium will decline in the medium term for the reasons mentioned above but production in 1976 should be near that for 1975. The expected growth in demand for selenium will probably result in a trend towards higher prices.

Prices

The producer prices for commercial grade and high-purity grade remained unchanged in 1975. The dealer prices for commercial grade were considerably below the producer price, largely because of weak demand. This price at the beginning of the year was quoted at U.S. $15.50 a pound and dropped to a low of $8.25 in August. At the end of the year the dealer price was U.S. $10.00 to $10.50 a pound.

Prices

According to *Metals Week*, United States selenium prices per pound for the year 1975 were as follows:

	Commercial Grade	High-Purity Grade
January 1 to December 31	$18.00	$21.00-22.00

Tariffs

Canada

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
92804-4	Selenium metal	5%	10%	15%	5%

United States

Item No.		
420.50	Selenium dioxide	free
420.52	Selenium salts	free
420.54	Other selenium compounds	5%
632.40	Selenium metal, unwrought, other than alloys, waste and scrap	free
632.84	Selenium metal alloys, unwrought	9%
633.00	Selenium metals, wrought	9%

European Communities

Item No.		Conventional Rate of Duty
28.04 C.11	Selenium metal	free

Sources: The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division. Tariff Schedules of the United States Annotated 1976, T.C. Publication 749. Official Journal of the European Communities, 24 November 1975.

TELLURIUM

Like selenium, tellurium is recovered in Canada from the tankhouse slimes of the two electrolytic copper refineries and the Port Colborne nickel refinery. It is refined by the same two companies; Canadian Copper Refiners Limited at Montreal East, Quebec, and The International Nickel Company of Canada, Limited, at Copper Cliff, Ontario.

Production of tellurium in all forms from Canadian ores in 1975 amounted to 80,000 pounds valued at $763,000, compared with 124,313 pounds valued at $1,009,422 in 1974. Tellurium is related to selenium output because tellurium is a coproduct of selenium recovery. Refined output from all sources including imported material for the years 1975 and 1974 was 90,348 pounds and 138,031 pounds, respectively.

Canadian Copper Refiners Limited has an annual capacity to produce 60,000 pounds of tellurium in the form of powder, stick, lump and dioxide. The Copper Cliff refinery has capacity to produce 18,000 pounds of tellurium a year in the form of dioxide.

Consumption and uses

Tellurium is recovered mainly as a byproduct of copper refining and the supply is, therefore, related to copper production. Under present technological practices a low ratio of recovery is obtained, but it is adequate to meet demand. Tellurium and many of its compounds are highly toxic and great care is required in handling these materials.

Most of the commercial-grade tellurium sold by the primary producers is in the form of slab, stick, lump,

Table 5. Canada, tellurium production and consumption, 1974-75

	1974		1975[p]	
	(pounds)	($)	(pounds)	($)
Production				
All forms[1]				
Quebec	87,990	714,479	49,000	470,000
Ontario	19,468	158,080	15,000	141,000
Manitoba	12,207	99,121	12,000	114,000
Saskatchewan	4,648	37,742	4,000	38,000
Total	124,313	1,009,422	80,000	763,000
Refined[2]	138,031	. .	90,348	. .
Consumption[3] (refined)	981	. .	1,354	. .

Source: Statistics Canada.
[1]Recoverable tellurium content of blister copper treated, plus refined tellurium from domestic primary material. [2]Refinery output from all sources, including imported material and secondary sources. [3] Available data, reported by consumers.
[p]Preliminary; . . Not available.

tablet and powder. It is also sold as copper and iron alloys.

In the United States consumption by major uses in 1975 was estimated to be: iron and steel products 70 per cent, nonferrous metal products 19 per cent, chemicals 6 per cent and other, 5 per cent.

The primary metal industries are by far the largest consumers of tellurium. Added to copper and low carbon and alloy steels, the machinability of these metals is greatly improved. In stainless steel castings it reduces or prevents pinhole porosity. A very small quantity of tellurium added to molten iron controls the chill depth of grey-iron castings. An alloy containing 99.5 per cent copper and 0.5 per cent tellurium is used in the manufacture of welding tips and communications equipment because it can be hot- or cold-worked, and the thermal and electrical conductivity is only slightly less than that of copper. Up to 0.1 per cent tellurium in lead forms an alloy that has better resistance to wear, vibration breakdown and corrosion, and, because of these properties, is used to sheathe marine cables and to line tanks subject to chemical corrosion.

Table 6. Canada, production and consumption of tellurium, 1966-75

	Production		Consumption
	All Forms[1]	Refined[2]	Refined[3]
	(pounds)		
1966	72,239	72,745	862
1967	73,219	70,105	981
1968	70,991	65,926	4,605
1969	62,048	72,664	3,532
1970	58,333	64,634	880
1971	24,488	43,558	1,178
1972	45,649	58,446	1,419
1973	92,284	93,205	1,222
1974	124,313	138,031	981
1975[p]	80,000	90,348	1,354

Source: Statistics Canada.
[1]Includes recoverable tellurium content of blister copper, not necessarily recovered in year designated; plus refined tellurium from domestic primary metal. [2]Refinery production from all sources, including imported material and secondary sources. [3]Available data, reported by consumers.
[p]Preliminary.

Tellurium, as a component of alloys containing gallium, bismuth and lead, is used in thermoelectric devices for the direct conversion of heat into electricity, and for cooling as a result of its Peltier effect. A thermonuclear heart pacemaker that employs the thermoelectric principle is under development. In the device, nuclear power provides heat and a tellurium alloy converts the heat to electrical energy. The minimum life of this experimental pacemaker is reported to be ten year.

Tellurium is used as a secondary vulcanizing agent in natural and synthetic rubber in which it increases toughness and resistance to abrasion and heat. These characteristics made possible its application for the jacketing of portable electric cable used in mining, dredging, and welding and for specialized conveyor belting. Tellurium is employed to eliminate porosity in thick rubber sections and as an accelerator for butyl applications.

Some tellurium is consumed in glass and ceramic production to develop blue-to-brown coloration, in the preparation of insecticides and germicides and in the manufacture of delay-electric blasting caps and pigments.

Table 7. Noncommunist world production of tellurium, 1973-75

	1973	1974	1975[e]
	(pounds)		
United States	241,000	191,000	130,000
Canada	92,000	124,000	80,000
Peru	58,000	60,000	50,000
Japan	54,000	57,000	40,000
Total	445,000	432,000	400,000

Sources: For Canada, Statistics Canada. For other countries, Preprint from the Bureau of Mines *Minerals Yearbook 1974;* U.S. Bureau of Mines Commodity Data Summaries, January 1976.
[e] Estimated.

Outlook

Supply is largely limited to that which is available from copper output and, as in the case of selenium, new copper production is increasingly derived from tellurium-poor ores. In the short-to-medium term a slow growth in demand is expected, in the range of zero to 2 per cent, and supply will be adequate to meet requirements. Substitutes are readily available for the major uses and will tend to constrain an increase in consumption and to hold price changes to modest increases.

Prices

According to *Metals Week*, the United States tellurium price per pound for slab in 150-pound lots was as follows:

January 1 to September 18	$9.00-$10.00
September 19 to December 31	$10.00

Tariffs

Canada

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
92804-5	Tellurium metal	5%	10%	15%	5%

United States

Item No.		
421.90	Tellurium compounds	5%
427.12	Tellurium salts	5%
632.48	Tellurium metal, unwrought, other than alloys, and waste and scrap (duty on waste and scrap suspended to June 30, 1975)	4%
632.84	Tellurium metal alloys, unwrought	9%
633.00	Tellurium metal, wrought	9%

European Communities

Item No.		Conventional Rate of Duty
28.04 C.111	Tellurium metal	2.4%

Sources: The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division. Tariff Schedule of the United States Annotated, 1976, T.C. Publication 749. Official Journal of the European Communities; 24 November 1975.

Silica

G.H.K. PEARSE

Silica (SiO_2) occurs as the mineral quartz in a variety of rocks and unconsolidated sediments. Although it is one of the most abundant minerals, making up an estimated 12 per cent of the earth's crust, commercial sources of silica are presently restricted to uncommonly pure sands, sandstones, quartzites and vein quartz. Further, because of its low unit value, an economically viable deposit should normally be mineable by low-cost, open-pit methods and, ideally, be located close to consuming areas in order to minimize transportation costs.

The principal uses for silica are: as the chief constituent in glass, as metallurgical flux, in the manufacture of silicon carbide, as an ore of silicon and ferrosilicon, as foundry sand for metal castings, in sand blasting, and as filler materials in tile, asbestos cement pipe, concrete and bricks.

Production of silica in Canada in 1975 was 2.56 million short tons, down 7 per cent from 1974. The record 3.2 million tons shipped in 1970 remains unsurpassed.

Most of the silica produced in Canada is low-value lump silica and silica sand consumed as metallurgical flux. High-quality silica sand suitable for the manufacture of glass is produced by two companies in Canada. Indusmin Limited, the largest, operates beneficiation plants in southern Ontario and Quebec. Steel Brothers Canada Ltd. quarries high-grade silica sandstone on Black Island in Lake Winnipeg and processes the material at the company's plant at Selkirk, Manitoba.

Canada imports high-grade silica sand for use in glass manufacturing, sand suitable for foundry castings, silica and crystallized quartz and silica brick. In 1975, imports, nearly all from the United States, totalled 1.15 million tons, 10 per cent more than in 1974.

Principal producers and developments

Newfoundland. Newfoundland Enterprises Limited, a subsidiary of Armand Sicotte & Sons Limited, produces silica from a quarry at Villa Marie on the Avalon Peninsula. The silica is hauled by truck about 12 miles to Long Harbour where it is used as a flux in the manufacture of elemental phosphorus by Erco Industries Limited. Erco's $40 million phosphorus plant requires about 100,000 tons of silica annually.

Quebec. Indusmin Limited produces a wide variety of silica products at its mill near Saint-Canut, Quebec. In addition to quarrying Potsdam sandstone adjacent to the Saint-Canut mill, the company quarries a friable Precambrian quartzite from a deposit near Saint-Donat. Material from the Saint-Donat quarry is trucked about 50 miles to the Saint-Canut mill for processing. Products produced at Saint-Canut include silica sand suitable for glass and silicon carbide manufacture, foundry sand, and silica flour for use as a filler in tiles, asbestos cement pipe, concrete blocks and bricks. The silica sand suitable for glass manufacture is marketed in Quebec, while much of the product suitable for use in the construction industry is sold in Ontario. The balance of Quebec's silica sand requirements for glass manufacture is imported from the United States.

Union Carbide Canada Mining Ltd. quarries quartzitic sandstone at Melochville, Beauharnois County, for use in ferrosilicon manufacture at Beauharnois. Fines from this operation are used in foundry work, cement manufacture and as a metallurgical flux.

During the year Baskatong Quartz Products Ltd. closed its plant which had produced lump silica and crushed quartz from a deposit on the southwest shore of Lake Baskatong. The lump silica was used in the manufacture of silicon metal and, to a lesser extent, as grinding pebble. The crushed quartz was sold for use as exposed aggregate in decorative concrete. A new 52,000-ton-a-year ferrosilicon plant is slated to come on stream at Bécancour, Quebec in 1976. The company, S.K.W. Electro-Metallurgy Canada Ltd. will obtain its raw material from a high-purity silica deposit 25 miles north of the Baie St-Paul near La Galette in Charlevoix County operated by Baskatong Quartz Products. The silica will be shipped by truck to Baie St-Paul and thence by rail for 140 miles to Bécancour. Silica production commenced in the fall of 1975 and totalled 12,000 tons by year-end. Output is expected to reach 20,000 tons in 1976.

Table 1. Canada, silica production and trade, 1974-75

	1974		1975^p	
	(short tons)	($)	(short tons)	($)
Production, quartz and silica sand[1]				
By province				
Quebec	771,014	5,388,238	493,000	5,338,000
Ontario	1,236,780	3,849,875	1,360,000	4,977,000
Manitoba	434,982	1,684,036	387,000	1,575,000
Alberta	. .	436,592	. .	762,000
Newfoundland	. .	375,000	. .	350,000
British Columbia	19,724	134,281	35,000	195,000
Saskatchewan	151,180	188,975	122,000	152,000
Nova Scotia	. .	127,500	. .	150,000
Total	2,762,028	12,184,497	2,561,000	13,499,000
By use				
Flux	1,388,804	1,778,925	. .	. .
Ferrosilicon	279,578	1,205,738	. .	. .
Glass and fiberglass	514,749	4,615,774	. .	. .
Other uses[2]	578,897	4,584,060	. .	. .
Total	2,762,028	12,184,497	. .	. .
Imports				
Silica sand				
United States	1,053,696	7,558,000	1,150,927	9,163,000
United Kingdom	41	4,000	62	6,000
Total	1,053,737	7,562,000	1,150,989	9,169,000
Silex and crystallized quartz				
United States	1,825	267,000	1,703	302,000
Brazil	. .	4,000	2	3,000
United Kingdom	—	—	4	. . .
Netherlands	7	9,000	—	—
Mexico	10	2,000	—	—
Total	1,842	282,000	1,709	305,000
Firebrick and similar shapes, silica				
Japan	3,822	1,356,000	6,032	3,535,000
United States	11,561	2,294,000	8,519	2,382,000
United Kingdom	155	19,000	3,414	1,102,000
West Germany	5	4,000	853	284,000
Netherlands	769	47,000	—	—
Total	16,312	3,720,000	18,818	7,303,000
Exports				
Quartzite				
United States	158,526	330,000	44,067	225,000
Total	158,526	330,000	44,067	225,000

Source: Statistics Canada.
[1]Producers' shipments include crude and crushed quartz, crushed sandstone and quartzite and natural silica sand. [2]Includes foundry use, sand blasting, silica brick, concrete products, chemical manufacture, building products and silicon carbide.
^{p}Preliminary; — Nil; . . Not available for publication; . . . Less than one thousand dollars.

Ontario. Indusmin Limited quarries a high-grade silica deposit on Badgeley Island in Georgian Bay. The deposit consists of very pure Precambrian Lorraine quartzite. A primary crushing plant at the deposit some 120 miles north of Midland, across Georgian Bay, and a grinding and processing plant at Midland came on stream during the first half of 1970. The Badgeley Island operation has a capacity of approximately 1 million tons a year of washed lump silica and fine material. The Midland plant capacity is about 500,000 tons a year of refined silica products. Primary products from the crushing plant on Badgeley Island are shipped directly to manufacturers of ferrosilicon and silicon metal, and to the Midland grinding plant for further processing. Products from the Midland plant go to glass, ceramic, chemical and other industries in Ontario.

The Midland plant has experienced difficulties from the start with crushing, grinding and classification circuits, the principal problem being the production of an unacceptable percentage of fines. The fines must be removed to meet glass grade specifications and research into uses for the large volume of fines is actively being pursued. Recent modification of the circuits has been successful in improving overall recovery and physical specifications of the glass sand product.

Manitoba. Steel Brothers Canada Ltd. quarries friable sandstone of the Winnipeg Formation at Black Island in Lake Winnipeg. The sandstone is then barged to the company's processing plant at Selkirk where it is washed, sized and packaged for sale. The company provides silica sand for a large portion of the western Canadian market. Silica sand suitable for the manufacture of glass containers is shipped to Alberta. The majority of the remaining production is consumed in the Manitoba market, largely as foundry sand. In addition to the silica sand operation, the company quarries quartzite and sand for The International Nickel Company of Canada, Limited's smelter at Thompson, Manitoba, for use as metallurgical flux.

Saskatchewan. Hudson Bay Mining and Smelting Co., Limited obtains silica for smelter flux from Pleistocene glacial sand deposits in Saskatchewan, adjacent to its operations at Flin Flon, Manitoba.

Alberta. Sil Silica Ltd. quarries Pleistocene dune sands at Bruderheim, 40 miles northeast of Edmonton. A washing and flotation plant upgrades material running 93 per cent silica, 3 per cent alumina, 1 per cent clay and 0.75 per cent iron oxide, to products suitable for fibreglass manufacture, sand blasting and foundry use. Since operations started in 1971 capacity has tripled to more than 60,000 tons a year. Reserves are adequate for many years.

British Columbia. In August 1968 Pacific Silica Limited ceased production of silica for ferrosilicon and silicon carbide at its deposit near Oliver, British Columbia. Stucco dash and roof chips are being produced from existing stockpiles.

Uses and specifications

The principal uses of lump silica, silica sand and crushed quartzite, together with specifications by consuming industry, are as follows:

Lump silica. *Silica flux.* Massive quartz, quartzite, sandstone and unconsolidated sands are used for flux in smelting base-metal ores where iron and basic oxides are slagged as silicates. Because free silica is the active slagging agent, the free silica content should be as high as possible. Minor amounts of impurities such as iron and alumina are tolerable. Lump silica used as a flux is usually minus one-plus 5/16 inch in size.

Silicon and silicon alloys. Lump quartz, quartzite and well-cemented sandstones are used in the manufacture of silicon, ferrosilicon and other silicon alloys. Lump silica 3/4 to 5 inches in size, obtained by crushing quartzite or indurated sandstone, is used in the manufacture of ferrosilicon. Chemical specifications are: silica, 98.0 per cent; alumina (Al_2O_3), less than 1.0 per cent: iron (Fe_2O_3) plus alumina, not over 1.5 per cent; lime and magnesia, each less than 0.2 per cent. Phosphorus and arsenic should be absent.

Silica brick. Quartz and quartzite crushed to minus 8 mesh are used in the manufacture of silica brick for high-temperature refractory furnaces. Chemical specifications for this use are: silica, 96 to 98 per cent; alumina, less than 0.1 per cent; combined iron and alumina, less than 1.5 per cent. Other impurities such as lime and magnesia should be low.

Aggregate. Crushed and sized quartz and quartzite are used as exposed aggregate in precast concrete panels for buildings, slabs, sidewalks and for other decorative landscape purposes.

Other uses. Lump quartz and quartzite are used as lining material in ball and tube mills and as lining and packing for acid towers. In some instances, naturally occurring quartzitic pebbles are used as grinding media in the crushing of various nonmetallic ores.

Silica sand. *Glass.* High-purity, natural-occurring sand or material produced by crushing quartzite or sandstone is used in the manufacture of glass. Minor amounts of certain elements are particularly objectionable because they act as powerful colorants. For example, chromium should not exceed six parts per million and cobalt not over two parts per million.

Silicon carbide. Silica sand used in the manufacture of silicon carbide should have a silica content of at least 99 per cent. Iron and alumina should be less than 0.1 per cent each; lime, magnesia and phosphorus should be absent. Sand, should be plus 100 mesh, with the bulk of it plus 35 mesh.

Table 2. Canada, silica production and trade, 1966-75

	Production	Imports		Exports	Consumption
	Quartz and[1] Silica Sand	Silica Sand	Silex or Crystallized Quartz	Quartzite	Quartz and Silica Sand
			(short tons)		
1966	2,299,660	1,013,285	288	156,038	3,372,668
1967	2,610,740	952,459	142	56,200	3,501,186
1968	2,554,565	1,107,000	116	64,086	3,684,424
1969	2,300,374	1,285,228	35	81,488	3,526,264
1970	3,238,037	1,296,537	205	64,945	4,386,433
1971	2,553,884	1,420,278	312	100,664	3,755,133
1972	2,663,836	1,368,845	9	137,569	3,935,666
1973	2,765,944	1,087,360	1,092	114,045	3,937,450
1974	2,762,028	1,053,737	1,842	158,526	4,222,915
1975[p]	2,561,000	1,150,989	1,709	44,067	. .

Source: Statistics Canada.
[1] Includes silica to make silica brick.
[p] Preliminary; . . Not available.

Hydraulic fracturing. Sand is used in the hydraulic fracturing of oil-bearing strata to increase open-pore spaces, thus increasing the productivity of the oil well. Sand utilized for this purpose should be clean and dry, have a high compressive strength, be free of acid-consuming constituents and have a grain size between 20 and 35 mesh. Grains should be well-rounded to facilitate placement in the formation in order to provide maximum permeability.

Foundry sand. Naturally occurring sand or material produced by crushing friable sandstone is used in the foundry industry for moulding. For foundry purposes, the chemical composition of the sand is not as important as its physical properties. For the end-use, a highly refractory sand having rounded grains with frosted or pitted surface is preferred. Grain sizes vary between 20 and 200 mesh. Rounded grains are preferable to angular fragments because they allow maximum permeability of the mould and maximum escape of gas during casting.

Sodium silicate. Sand for the manufacture of sodium silicate should contain more than 99 per cent silica, less than 0.25 per cent alumina, less than 0.05 per cent lime and magnesia combined, and less than 0.03 per cent iron (Fe_2O_3). All sand should be between 20 and 100 mesh.

Other minor users. Coarsely ground, closely sized quartz, quartzite, sandstone and sand are used as abrasive grit in sandblasting and in the manufacture of sandpaper. Various grades of sand are used as filtering media in water-treatment plants; silica is also required in portland cement manufacture if there is insufficient silica in the limestone or in other raw material used in the process.

Silica flour. Silica flour, produced by the fine grinding of quartzite, sandstones and lump quartz, is used in the ceramics industry for enamel frits and pottery flint. For use in enamels, the silica flour must be over 97.5 per cent silica, with alumina (Al_2O_3) less than 0.5 per cent and iron (Fe_2O_3) less than 0.2 per cent. Silica flour is also used as an inert filler in rubber and asbestos cement products, as an extender in paints and as an abrasive agent in soaps and scouring pads. It is used increasingly in autoclave-cured concrete products such as building blocks and panels, approximately 45 pounds of silica flour being used for each 100 pounds of portland cement consumed.

Quartz crystal. Quartz crystal with desirable piezo-electric properties is used in radio-frequency control, radar and other electronic devices. Natural crystal for this purpose must be perfectly transparent and free from all impurities and flaws. The individual crystals should weigh 100 grams or more and measure at least two inches in length and one inch or more in diameter. Much of the world's crystal requirement has been met by natural crystal from Brazil; however, natural crystal is being rapidly replaced by excellent-quality, synthetic crystal grown in the laboratory from quartz "seed". Artificial quartz crystals are oriented for the cutter prior to delivery. The high degree of purity permits product yields at least four times that of natural quartz crystal.

There is no production of quartz crystal in Canada, and only a small demand exists. Domestic requirements are met mainly by imports, chiefly from the United States, with minor amounts from Brazil. Quartz Crystals Mines Limited, Toronto produced minor amounts from an occurrence near Lyndhurst, Ontario, several years ago.

Table 3. Canada, available data on consumption of silica, by industries, 1973-74

	1973ʳ	1974
	(short tons)	
Smelter flux[1]	1,485,230	1,388,804
Glass manufacture (incl. glass fibre)	752,825	800,386
Foundry sand	927,687	1,155,610
Artificial abrasives	179,609	167,228
Ferrosilicon	149,903	171,606
Metallurgical use	79,798	64,503
Concrete products	17,986	15,742
Gypsum products	10,774	9,837
Asbestos products	47,987	43,651
Chemicals	25,170	25,258
Fertilizer, stock, poultry feed	7,339	19,357
Other	253,142	345,066
Total	3,937,450	4,207,048

Source: Statistics Canada for source data. Classification by Statistics Section, Mineral Development Sector, Department of Energy, Mines and Resources, Ottawa.
[1]Producers' shipments of quartz and silica for flux purposes.
ʳ Revised.

A quartz-crystal stockpile of 182.8 tons was sold by the Canadian Government during 1974.

Outlook

The economic downturn which started in late 1974 continued through 1975. The 200,000-ton decrease in production, coupled with a 100,000 ton decrease in exports and a similar tonnage increase in imports, indicated that Canadian consumption was unchanged from that of 1974. Expected increases in output from Indusmin's operations in both Ontario and Quebec, further development of the La Galette operation in Quebec to meet the needs of the new SKW plant and increased output from Sil Silica's operation in Alberta in response to growing demand for fibreglass insulation should boost Canada's silica production to the 1974 level of output. Although silica reserves are large and there is scope for displacing imports, full capacity utilization and further expansion in the industry must await significant economic recovery.

Tariffs

Canada

Item No.		
29500-1	Ganister and sand	free
29700-1	Silex or crystallized quartz, ground or unground	free

United States

Item No.		(¢ per lt)
513.11	Sand containing 95% or more silica, and not more than 0.6% of oxide of iron	
	On and after Jan. 1, 1972	25
513.14	Sand, other	free
514.91	Quartzite, whether or not manufactured	free
523.11	Silica, not specially provided for	free

Sources: For Canada, The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa. For United States, Tariff Schedules of the United States Annotated (1976), T.C. Publication 749.

Silicon, Ferrosilicon, Silicon Carbide and Fused Alumina

MICHEL A. BOUCHER

Demand for ferrosilicon was strong during most of the year but slackened at the end, a situation that is expected to continue until mid-1976. The demand for ferrosilicon depends on steel production and world steel production declined by some 7 per cent in 1975. Demand for silicon carbide was strong in 1974, but slackened considerably in 1975, with plants in Canada operating at about 80 per cent capacity. A stronger demand is expected in 1976.

Canada, production, development and consumption

The production of silicon, ferrosilicon, silicon carbide and fused alumina are all energy-intensive. Canada is an important producer and exporter of all products. In Canada there are two producers of ferrosilicon; Union Carbide Canada Limited, with plants at Beauharnois and Chicoutimi, Quebec, and Chromasco Limited, with a plant at Beauharnois, Quebec. Union Carbide is the only company in Canada that makes silicon metal for use by the aluminium, copper alloys and steel industries. Union Carbide is the major supplier of silicon to the Aluminum Company of Canada, Limited, which consumes on the average six pounds of silicon per ton of aluminium produced.

In May 1976, Seuddeutsche Kalkstickstoff-Werke (SKW), a West German subsidiary of Hoechst AG, will start the production of ferrosilicon and silicon at its plant at Becancour where some 25,000 tons of each product will be produced. About half the production is expected to be marketed in North America, mainly in the United States, and the remainder will be marketed in Europe and Japan.

Combined production of crude silicon carbide, crude fused alumina and crude zirconia-alumina in Canada and the United States in 1974, were respectively 163,000 tons*, 241,000 tons and 25,000 tons. In 1975, production was reduced to 134,000 tons, 141,000 tons and 17,000 tons. Some 70 per cent of the total production of each product comes from Canada.

Production of crude silicon carbide and crude fused alumina in Canada is concentrated in Quebec and Ontario. All of Canada's production of both products is exported to the United States. Most is shipped to the eastern part of the United States mainly to Worcester, Massachusetts, Tonawanda, Buffalo and Niagara Falls, all in New York State. There the crude material is crushed, separated magnetically or through selective settling of particles in water for powder sizes, and then screened. A small portion comes back to Canada where it is used to make bonded abrasives such as grinding wheels and coated abrasives such as sand paper. Bauxite, petroleum coke and silica sand are the major raw materials required to produce crude silicon carbide and crude fused alumina. They are almost all imported. In 1973, Canada's shipments of crude silicon carbide amounted to 118,281 tons valued at $18,985,000 or approximately $160 a ton. Canadian consumption of refined silicon carbide used to make abrasive products was 1,982 tons valued at $904,000 for an average of $456 a ton. Canada's shipments of crude fused alumina amounted to 171,236 tons, valued at $25,986,000 or approximately $152 a ton. Canadian consumption of refined aluminum oxide used to make abrasive products was 5,195 tons valued at $1,897,000 or $365 a ton.

The Canadian producers of crude silicon carbide and crude fused alumina in Canada are shown in Table 1.

In 1973, the most recent year for which statistics are available, Canada's shipments of abrasive wheels were valued at $14,913,000, the value of abrasive cloth shipments was $9,557,000 and abrasive paper was $9,099,000. Shipments of other coated abrasive products were valued at $3,848,000.

In Canada, the major consumers of abrasive wheels are located in Ontario; they account for more than 50

* The short ton of 2,000 pounds is used throughout unless otherwise stated.

Table 1. Canada, crude silicon carbide and crude fused alumina production facilities, 1975

Producer	Plant Location	Product
Canadian Carborundum Company, Limited	Shawinigan, Que. Niagara Falls, Ont.	Silicon carbide Fused alumina
Norton Company of Canada, Limited	Cap-de-la-Madeleine, Que. Chippawa, Ont.	Silicon carbide Fused alumina, Silicon carbide, Zirconia-alumina
Electro Refractories & Abrasives Canada Ltd.	Cap-de-la-Madeleine, Que.	Silicon carbide
Exolon Company of Canada, Ltd.	Thorold, Ont.	Silicon carbide, fused alumina, Zirconia-alumina
General Abrasive (Canada) Ltd.	Niagara Falls, Ont.	Fused alumina, silicon carbide
Simonds Abrasive Division, Wallace-Murray Canada, Limited	Arvida, Que.	Fused alumina

Source: Mineral Development Sector, Department of Energy, Mines and Resources, Ottawa.

per cent of Canadian consumption. Quebec-based industry accounts for about 25 per cent. The Canadian consumption of abrasive wheels is estimated at $25 million a year. Following is a list of the major Canadian producers of abrasive wheels, all located in Ontario:

Producer	Location
Dresser Bay State Abrasives Canada Limited	Brantford
Simonds Abrasives Division Wallace-Murray Canada Limited	Brockville
Norton Company of Canada, Limited	Hamilton
The Wright Abrasives Limited	Hamilton
Canadian Grinding Wheel Company Limited	Hamilton
Midwest Abrasives Ltd.	Strathroy

During 1975, Union Carbide's production was affected by a strike that lasted for more than half the year. Another event of importance was the negotiations between Simonds Abrasives and Unicorn Industries of England. Unicorn, the third largest manufacturer of abrasives in the world, announced plans to buy the plant of Simonds at Brockville, Ontario. Also, during 1975, Dresser Industries, Inc. and Ferro Corp., two conglomerates with diversified holdings in metalworking and other industries, were working on a joint venture to purchase General Abrasives. Dresser, the third largest manufacturer of abrasive wheels in the United States, does not have its own supply of raw materials. The company buys its raw materials from several sources and also from its two major competitors, Norton Co. and Carborundum Co., the two largest manufacturers of grinding wheels in the United States.

World developments

There are several silicon and ferrosilicon projects under construction in the world or planned for the next few years. Consolidated Gold Fields Australia Ltd. plans to build a plant in Tasmania, Australia that would produce some 50,000 tons a year of Fe-Si by 1976. The plant will be built in cooperation with A/S Fesil Co., a Norwegian producer of ferrosilicon. International Minerals & Chemical Corporation and Allegheny Ludlum will build a 70,000-ton-a-year ferrosilicon plant in 1977. Union Carbide and the government of Iceland have agreed to build a plant in Iceland that would produce 52,000 tons of ferrosilicon a year by 1977.

Other companies planning new plants for 1976-77 include: Sandur Manganese & Iron of India, a 24,000-ton-a-year ferrosilicon facility at Karnatoka, India; Nippon Refining & Concentrating, a 16,000-ton-a-year ferrosilicon plant at Kohma, Japan; Yakushima Denko, a 20,000-ton ferrosilicon plant at Yakushima, Japan and Electro Alloy Corp., a 12,000 ton ferrosilicon facility at Mindanao, Philippines. Also, Hevensa in Venezuela will add 20,000 tons to its present 30,000-ton annual

Table 2. Canada, ferrosilicon, silicon carbide and some other ferroalloys[1], exports and imports, 1974-75

	1974		1975^p	
	(short tons)	($)	(short tons)	($)
Exports				
Ferrosilicon				
United States	32,695	4,754,000	18,854	5,175,000
United Kingdom	15,650	3,878,000	11,483	2,456,000
Angola	607	55,000	795	140,000
Dominican Republic	227	78,000	175	106,000
Venezuela	12	11,000	32	38,000
Philippines	168	15,000	217	38,000
Puerto Rico	—	—	50	29,000
Japan	529	229,000	—	—
Other countries	820	296,000	155	42,000
Total	50,708	9,316,000	31,761	8,024,000
Silicon carbide, crude and grains				
United States	100,884	15,827,000	85,053	16,921,000
United Kingdom	145	27,000	395	143,000
Brazil	128	21,000	248	103,000
Greece	55	11,000	193	40,000
West Germany	—	—	20	7,000
Dominican Republic	—	1,000	—	—
Total	101,212	15,887,000	85,909	17,214,000
Ferroalloys, nes				
United States	2,447	1,492,000	640	661,000
United Kingdom	298	356,000	39	165,000
Netherlands	11	1,000	108	165,000
Argentina	112	439,000	102	145,000
Poland	—	—	19	81,000
Australia	112	357,000	58	66,000
Columbia	2	15,000	6	23,000
Other countries	827	532,000	401	70,000
Total	3,809	3,192,000	1,373	1,376,000
Imports				
Ferrosilicon				
United States	4,919	2,513,000	21,134	9,017,000
Yugoslavia	4,553	1,581,000	4,155	3,413,000
Norway	1,604	811,000	2,435	2,121,000
Spain	—	—	637	657,000
France	354	217,000	287	244,000
Other countries	210	171,000	401	213,000
Total	11,640	5,293,000	29,049	15,665,000
Silicomanganese, including silico spiegel				
United States	471	180,000	6,318	3,230,000
South Africa	126	21,000	—	—
Total	597	201,000	6,318	3,230,000

Table 2. (concl'd)

Imports (cont'd)	1974 (short tons)	1974 ($)	1975p (short tons)	1975p ($)
Ferroalloys, nes				
Dominican Republic	3,019	3,092,000	5,232	8,090,000
United States	5,986	5,029,000	3,037	3,171,000
France	1,421	928,000	1,139	1,273,000
Brazil	274	997,000	252	1,059,000
West Germany	110	131,000	87	109,000
United Kingdom	60	181,000	41	90,000
Switzerland	—	—	1	2,000
Greece	8,619	6,878,000	—	—
Other countries	21	21,000	—	—
Total	19,510	17,257,000	9,789	13,794,000

Source: Statistics Canada.
[1]Important other ferroalloys are discussed in the mineral reviews of the respective metals; e.g., those of manganese, nickel, titanium.
nes Not elsewhere specified; — Nil; p Preliminary.

silicon production capacity by 1977. These ferrosilicon plants are expected to cost, on the average, $1,000 per annual ton capacity.

Table 3. Ferrosilicon production and trade, 1973

	Production	Imports	Exports
	(short tons, gross weight)		
Austria	. .	16,842	. .
Belgium and Luxembourg	. .	41,200	. .
Canada	. .	14,242	50,814
France	. .	. .	90,497
West Germany	. .	159,438	16,649
India	26,746	. .	2,232
Italy	. .	31,658	. .
Japan	. .	52,749	1,974
Norway	. .	. .	306,842
South Africa	. .	. .	40,206
Sweden	63,807	24,310	35,738
United Kingdom	. .	129,847	492
United States	700,299	100,481	15,984
U.S.S.R.	. .	. .	163,583
Yugoslavia	. .	. .	48,321

Sources: *Metal Bulletin*, Handbook 1975; for Canada, Statistics Canada; for U.S., Bureau of Mines *Minerals Yearbook*, Preprint 1974.
. . Not Available.

Uses

Silicon is used in the production of aluminium alloys, in steel production and to a smaller extent in copper alloys production. Most of the ferrosilicon is used as an additive by the steel industry. Also, about 1 pound of 75 per cent ferrosilicon is required for each pound of magnesium produced. Silicon carbide is used in the manufacture of abrasive products and as a substitute for ferrosilicon in steel production. Aluminium oxide is used in the manufacture of abrasive products.

Table 4. Canada, ferrosilicon production[1] 1966-1974

	Ferrous Industry[2]	Other Industries[3]	Total
1966	53,263	16,547	69,810
1967	42,387	12,609	54,996
1968	78,456	10,392	88,848
1969	77,587	12,599	90,186
1970	86,352	8,914	95,266
1971	71,984	14,405	86,389
1972	77,026	13,299	90,325
1973	75,146	23,201	98,347
1974	73,788	31,044	104,832

Source: Statistics Canada.
[1]Producers' shipments; [2]Estimated by the Mineral Development Sector, Department of Energy, Mines and Resources, Ottawa. [3]Principally abrasives industry.

Table 5. Canada, consumption, exports and imports of ferrosilicon, 1966-75

	Consumption	Exports		Imports	
	(short tons)	(short tons)	($)	(short tons)	($)
1966	37,664	38,023	3,784,105	5,877	1,629,368
1967	34,807	41,929	4,189,328	21,740	3,534,000
1968	51,449	47,215	5,424,665	9,816	2,615,000
1969	50,737	48,499	5,257,000	9,050	2,010,000
1970	55,728	49,984	8,284,000	10,446	2,386,000
1971	43,619	53,150	8,699,000	10,380	2,679,000
1972	46,594	53,295	7,188,000	9,564	2,663,000
1973	61,520	51,339[r]	6,836,000[r]	14,242	4,135,000
1974	65,764	50,708[r]	9,316,000[r]	11,640	5,293,000
1975[p]	. .	31,761	8,024,000	29,049	15,665,000

Source: Statistics Canada.
[p] Preliminary; [r] Revised; . . Not available.

Outlook

An overcapacity for the production of ferrosilicon is probable for 1977 because several plants will come on stream at the same time. The steel, aluminium and copper industries are just recovering from a recession and will not be able to absorb the new production of ferrosilicon by that time.

Prices

Prices for 50 per cent and for 75 per cent ferrosilicon remained almost the same during the year at 32.5 cents a pound and 36.5 cents a pound respectively. Silicon prices decreased from 55 cents a pound in 1974 to 42 cents a pound in 1975. The price of refined silicon carbide, abrasive grade, changed from $732 — $852 a long ton in 1974 to $787 — $798 in 1975. Refined brown fused alumina decreased from $420 — $444 a long ton to $380 — $420.

Table 6. Canada, manufacturers' shipments of crude silicon carbide 1965-74

	Crude Silicon Carbide	
	(short tons)	($)
1965	98,545	13,967,000
1966	108,351	14,777,000
1967	96,212	13,564,000
1968	109,174	16,192,000
1969	108,197	15,815,000
1970	114,764	17,653,000
1971	103,484	15,798,000
1972	114,808	17,880,000
1973	118,281	18,985,000
1974	112,766	21,908,000

Source: Statistics Canada.

Table 7. Canada, exports of silicon carbide, crude and grains, 1965-75

	(short tons)	($)
1965	90,902	12,243,784
1966	98,878	12,831,523
1967	87,166	11,461,930
1968	102,924	14,690,146
1969	103,501	14,974,000
1970	105,996	15,976,000
1971	93,859	13,593,000
1972	104,388	15,051,000
1973	102,496	15,666,000
1974	101,212	15,887,000
1975[p]	85,909	17,214,000

Source: Statistics Canada.
[p] Preliminary.

Table 8. Canada, manufacturers' shipments of crude fused alumina, 1965-74

	(short tons)	($)
1965	169,289	19,635,000
1966	183,917	21,036,000
1967	151,310	17,620,000
1968	141,180	17,337,000
1969	164,321	19,993,000
1970	144,804	18,088,000
1971	124,488	16,159,000
1972	154,917	21,198,000
1973	171,236	25,986,000
1974	191,921	34,679,000

Source: Statistics Canada.

Table 9. Canada, exports of fused alumina, crude and grains, 1965-75

	(short tons)	($)
1965	177,287	20,159,149
1966	196,840	22,520,694
1967	167,181	19,482,573
1968	158,617	19,385,395
1969	184,956	24,508,870
1970	168,182	23,234,285
1971	135,199	19,096,000
1972	176,530	24,967,000
1973	188,850	29,923,000
1974	202,792	33,807,000
1975[p]	135,156	25,746,000

Source: Statistics Canada.
[p] Preliminary.

Prices published by Metals Week in December 1974 and 1975

			1974	1975
			(U.S.¢)	(U.S.¢)
Ferrosilicon, pound contained silicon, fob shipping point, freight equalized to nearest main producer, carload lots, lump bulk				
	High-purity	(%Si)		
		75	38.5	36.5
		85	. .	. .
		90	. .	. .
	Regular	50	33.5	32.5
Silicon metal, pound contained silicon, fob shipping point, freight equalized to nearest main producer, carload lots, lump bulk				
	(% max. Fe)	(% max. Ca)		
	0.35	0.07	59.9	46.4
	0.50	0.07	58.2	. .
	1.00	0.07	55.0	42.25
Magnesium ferrosilicon 44/48 Si				
	(%Mg)	(%Ce)		
	9		. .	. .
	9	0.5	. .	. .
	5	0.5	. .	. .
35-40 zirconium silicon			51.00	. .

Prices published by American Metal Market in December 1974 and 1975.

	1974	1975
	(U.S.¢)	(U.S.¢)
SMZ alloy: 60-65% Si, 5-7% Mn, 5-6% Zr, 15-ton lots, per pound of alloy	33.0	33.0
Calcium-silicon and calsibar alloy, fob producer, 15-ton lots, per pound	57.0	57.0
Electric furnaces silvery pig iron, fob Niagara Falls	(U.S.$)	(U.S.$)
16% Si, per ton	105.00	190.00
22% Si, per gross ton	121.00	212.00

Prices published by Industrial Minerals

(long ton, cif main European port)

	Dec. 1973	Dec. 1974	Dec. 1975
	(£)	(£)	(£)
Fused alumina, 8-220 mesh, cif			
Brown, min. 94% Al_3O_3	120-130	175-185	190-210
White, min. 99.5% Al_2O_3	130-150	205-220	235-250
Silicon carbide, 8-220 mesh, cif			
Black, about 99% SIC	180-210	305-355	375-380
Green, over 99.5% SIC	. .	. .	475-480

. . Not available.

Table 10. Tariff Profile (Most favoured nation — comparative ad valorem equivalents)

Brussels Tariff Nomenclature	Description	United States	European Economic Community	Japan	Canada
28.04	Silicon	5 to 9%	6.4%	6 to 12%	15%
28.56	Silicon carbide	free (crude) 0.4¢/lb (refined, ground)	8.6%	7.5%	free
28.20	Aluminium oxide	free (crude) 0.4¢/lb (refined, ground)	8.8%	free	free
68.06	Sand paper: sheet, strip	3.0%	4.5%	12%	17.5%
68.04	Abrasive wheels	10¢/lb +8.5%	5%	6%	17.5%
73.02	Ferrosilicon				
	Low-medium grade	free			free
	Medium-high grade*	2.3 to 4.5%			3.4%
	High purity*	10%			12.5%
	Ferrosilicon chromium	10%	7%	5%	5%
	Ferrosilicon maganese ƒ	8%	5-1/2%	5%	5%
	Ferrosilicon titanium	5%	7%	5%	5%
	Ferrosilicon tungsten ƒ	10%	7%	5%	5%
	Others**	5%	7%	5%	5%

* Ad valorem equivalents for the United States and Canada are based on values of 22¢ a lb for medium-to high-grade ferrosilicon, and 20.5¢ a lb for high-purity ferrosilicon.
** Others include a variety of ferrosilicon and silicon alloys (e.g. calcium silicon).
ƒ United States tariffs on these materials are compounded, the specific portion of the tariff being based on the manganese and tungsten content.
Source: Mineral Development Sector, Department of Energy, Mines and Resources, Ottawa.

Silver

J.G. GEORGE

Canada's primary* production of silver in 1975, estimated at 39,101,000 ounces**, was 3.71 million ounces less than in 1974. The decrease was mainly attributable to reduced output of several base-metal mines which produce silver as a byproduct. Much lower production by Echo Bay Mines Ltd. at its silver-copper property near Port Radium in the Northwest Territories also contributed to the lower Canadian output. Output in the Cobalt area of northern Ontario was little more than half of that produced in 1974. Increases in output in New Brunswick, Quebec, Saskatchewan, British Columbia and the Yukon Territory were more than offset by declines in the other silver-producing provinces and the Northwest Territories. Ontario was again, by far, the leading silver-producing province, primarily because of the substantial byproduct silver produced at the Kidd Creek base-metal mine of Texasgulf Canada Ltd. near Timmins. The value of Canadian production was $176.6 million, or $21.6 million less than in 1974 because of reduced output.

Canada's exports of silver in ores and concentrates and as refined metal totalled 38,039,147 ounces in 1975, or 2.68 million ounces less than the corresponding amount in 1974. The United States continued to be the major market, importing almost 80 per cent of Canada's total exports. Canadian imports of refined silver declined from 29,246,076 ounces in 1974 to 13,534,976 ounces in 1975. Most of the imports came from the United States with minor quantities coming from the United Kingdom and Costa Rica.

According to Statistics Canada, Canadian consumption of silver for both industrial and coinage uses was 10.62 million ounces in 1975, compared with 10.67 million ounces in 1974. It may be that each of these figures has been underestimated by 5 to 6 million ounces, mainly for the reason that insufficient amounts were allocated for coinage use.

Domestic production

Mine Production. The principal source of silver was again base-metal ores, which accounted for over 98 per cent of total production. The major portion of the remaining two per cent came from silver-cobalt ores mined in the Cobalt district of northern Ontario and the balance was byproduct recovery from lode and placer gold ores. The principal mine producers of silver in Canada are listed in Table 4 and the accompanying map shows their approximate locations. The four largest producers in order of output were Texasgulf Canada Ltd. in Ontario, Brunswick Mining and Smelting Corporation Limited in New Brunswick, and Cyprus Anvil Mining Corporation and United Keno Hill Mines Limited in the Yukon Territory. Base-metal ores mined by these four producers accounted for almost 46 per cent of total Canadian silver production. The largest producer in the Cobalt area of northern Ontario was Teck Corporation Limited, Silverfields Division, with output of 471,050 ounces.

* As reported by Statistics Canada and defined in Footnote 1 of Table 1 herein.

** Wherever used in this review, the term "ounce" refers to the "troy ounce".

Metal production. Production of refined silver in 1975 at the five Canadian primary silver refineries was as follows:

	Production[1] Refined Silver	Annual Rated Capacity[2]
	(troy ounces)	
Brunswick Mining and Smelting Corporation Limited, Smelting Division, Belledune, New Brunswick	2,195,000[3]	2,500,000
Canadian Copper Refiners Limited, Montreal East, Quebec	19,835,000[3]	25,000,000
Cominco Ltd., Trail, British Columbia	8,813,000	12,000,000
Royal Canadian Mint, Ottawa, Ontario	161,766[4]	7,000,000[5]
The International Nickel Company of Canada, Limited, Copper Cliff, Ontario	1,900,000[6]	. .

[1]Production of refined silver includes silver produced or derived from domestic and imported ores and concentrates as well as secondary materials. The largest portion of such refined silver was, however, derived from domestic ores and concentrates. Figures were obtained from annual reports of companies and of the Royal Canadian Mint. [2]As at December 31, 1975. [3]All of the refined silver bullion produced by Brunswick Mining and Smelting Corporation Limited was shipped to Canadian Copper Refiners Limited at Montreal East, Que., for further refining; and the 19,835,000 ounces of silver reported as production for Canadian Copper Refiners Limited (CCR) includes all of that silver bullion produced by Brunswick and refined by CCR in 1975. [4]Silver derived from refining gold bullion. [5]Total capacity for producing refined gold and silver, of which about 10% is silver. [6]Silver delivered to markets.
. . Not available.

Canadian Copper Refiners Limited at Montreal East, Quebec, was Canada's largest producer of refined silver, recovering it mainly from the treatment of anode and blister copper and the further refining of lower-grade silver bullion. The silver refinery of Cominco Ltd. at Trail, British Columbia, was the second-largest producer, recovering byproduct silver in the processing of its own, as well as custom, lead and zinc ores and concentrates. Cominco's refined silver output was substantially higher than that of 1974 because of a four-month shutdown in 1974 of its metallurgical plants at Trail, resulting from a labour strike. Other producers of refined silver were The International Nickel Company of Canada, Limited, at Copper Cliff, Ontario (from nickel-copper concentrates); and the Royal Canadian Mint at Ottawa, Ontario (from gold bullion). At Belledune, New Brunswick, Brunswick Mining and Smelting Corporation Limited, Smelting Division, recovered byproduct silver bullion from lead concentrates treated in a blast furnace.

At its electronic materials plants at Trail, B.C., Cominco Ltd. also produced high-purity silver metal with metallic impurities totalling one part per million or less. This specialty metal product was manufactured mainly for applications in the electronics industry such as solder preforms, brazing preforms and lead wire.

Table 1. Canada, silver production, trade and consumption, 1974-75

	1974		1975^p	
Production[1]	(ounces)	($)	(ounces)	($)
By province and territories				
Ontario	17,852,419	82,638,847	14,506,000	65,525,000
Yukon Territory	5,789,783	26,800,905	6,516,000	29,434,000
British Columbia	5,841,995	27,042,595	6,076,000	27,447,000
New Brunswick	4,464,463	20,666,000	4,790,000	21,638,000
Quebec	2,970,356	13,749,777	3,245,000	14,656,000
Northwest Territories	3,817,207	17,669,851	2,174,000	9,821,000
Manitoba	1,267,403	5,866,808	994,000	4,492,000
Newfoundland	555,689	2,572,284	528,000	2,384,000
Saskatchewan	225,203	1,042,465	272,000	1,230,000
Nova Scotia	25,190	116,605	—	—
Alberta	13	60	—	—
Total	42,809,721	198,166,197	39,101,000	176,627,000

Table 1. (concl'd)

	1974		1975P	
	(ounces)	($)	(ounces)	($)
By source				
Base-metal ores	41,320,915	191,274,291	38,457,335	173,713,000
Gold ores	206,186	954,657	209,272	947,000
Silver-cobalt ores	1,280,655	5,928,155	434,287	1,962,000
Placer gold ores	1,965	9,094	106	5,000
Total	42,809,721	198,166,197	39,101,000	176,627,000
Refined silver[2]	27,177,366	. .	28,995,022	. .
Exports				
In ores and concentrates				
United States	10,815,538	32,264,000	7,420,821	27,354,000
Japan	5,510,429	21,603,000	4,527,337	19,710,000
West Germany	880,202	2,608,000	1,421,289	4,332,000
Belgium-Luxemburg	947,677	2,853,000	897,679	2,434,000
Netherlands	563,401	507,000	358,610	325,000
Italy	166,564	382,000	174,032	470,000
Others	494,322	1,324,000	297,702	1,230,000
Total	19,378,133	61,541,000	15,097,470	55,855,000
Refined metal				
United States	20,724,890	96,333,000	22,567,975	100,062,000
Cuba	—	—	100,319	203,000
Jamaica	89,384	411,000	100,174	521,000
United Kingdom	116,102	391,000	96,650	449,000
Trinidad-Tobago	70,299	342,000	61,528	289,000
Other	338,075	1,148,000	15,031	64,000
Total	21,338,750	98,625,000	22,941,677	101,588,000
Imports				
Refined metal				
United States	23,615,251	104,980,000	13,330,228	58,936,000
United Kingdom	5,000,268	15,752,000	160,162	747,000
Costa Rica	—	—	31,713	174,000
Other	630,557	2,910,000	12,873	66,000
Total	29,246,076	123,642,000	13,534,976	59,923,000
Consumption, by use				
Sterling	2,253,335	. .	1,625,432	. .
Silver alloys	1,845,481	. .	2,952,356	. .
Wire and rod	99,748	. .	43,269	. .
Other[3]	6,472,719[4]	. .	5,995,680[4]	. .
Total	10,671,283[4]	. .	10,616,737[4]	. .

Source: Statistics Canada.
[1]Includes recoverable silver in: ores, concentrates and matte shipped for export; crude gold bullion produced; blister and anode copper produced at Canadian smelters; base bullion produced from domestic ores; and silver flotation concentrates treated at domestic smelters. [2]From all sources, domestic and imported materials of both primary and secondary origin. [3]Includes sheet, silver salts, coinage and miscellaneous uses. [4]Includes silver used in Cdn. silver dollars but excludes silver used in Olympic.
P Preliminary; — Nil; . . . Not available.

Table 2. Canada, silver production, trade and consumption, 1966-75

	Production		Exports			Imports, Refined Silver	Consumption[3] Refined Silver
	All Forms[1]	Refined[2] Silver	In Ores and Concentrates	Refined Silver	Total		
				(troy ounces)			
1966	33,417,874	21,298,325	11,850,469	12,221,142	24,071,611	14,477,787	21,303,704
1967	36,315,189	20,658,556	10,407,418	13,735,675	24,143,093	5,383,872	14,576,608
1968	45,012,797	34,611,344	21,502,022	28,104,562	49,606,584	14,060,635	13,598,358
1969	43,530,941	38,678,520	21,883,028	34,658,937	56,541,965	19,168,785	5,747,068
1970	44,250,804	30,725,450	21,819,924	24,199,524	46,019,448	4,319,357	6,034,028
1971	46,023,570	20,544,196	25,562,579	18,201,371	43,763,950	722,815	7,050,956
1972	44,792,209	22,740,796	22,143,806	19,825,475	41,969,281	1,217,678	8,424,314
1973	47,487,589	25,596,479	26,202,059	22,904,893	49,106,952	8,754,786	16,870,929
1974	42,809,721	27,177,366	19,378,133	31,338,750	40,716,883	29,246,076	10,671,283[4]
1975[p]	39,101,000	28,995,022	15,097,470	22,941,677	38,039,147	13,534,976	10,616,737[4]

Source: Statistics Canada.
[1]Includes recoverable silver in: ores, concentrates and matte shipped for export; crude gold bullion produced; blister and anode copper produced at Canadian smelters; base bullion produced from domestic ores; and silver flotation concentrates treated at domestic smelters. [2]From all sources, domestic and imported materials of both primary and secondary origin. [3]Includes consumption for coinage. [4]Includes silver used in Cdn. silver dollars but excludes silver used in Olympic silver coins.
[p]Preliminary.

World production, consumption and economic factors

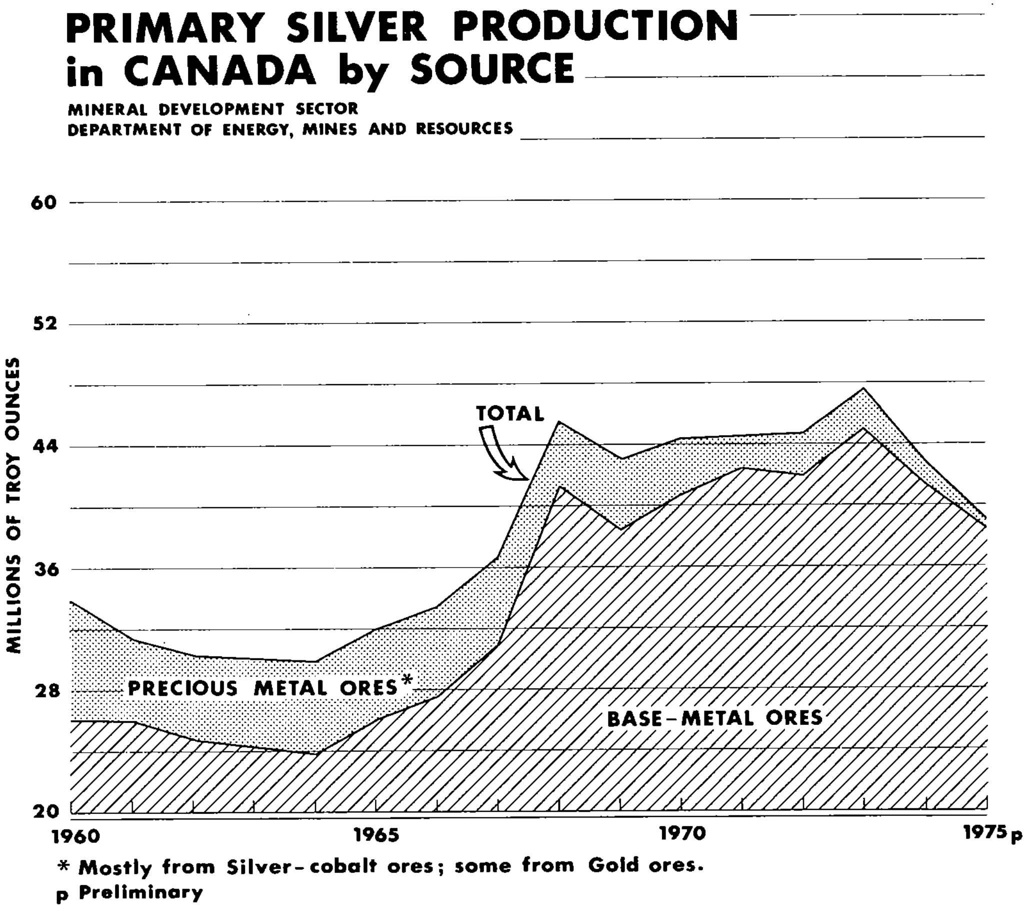
New production of silver in the noncommunist world in 1975, according to an estimate of Handy & Harman*, was 235.0 million ounces, or 6.5 million ounces less than in 1974. In 1975 noncommunist world consumption for both industrial and coinage uses was 390.0 million ounces, compared with 459.9 million ounces consumed in 1974. The gap between new production and consumption was 155 million ounces, or considerably less than in 1974. It could be, however, that noncommunist world production of silver for 1975 has been overestimated by some 5 million ounces.

Consumption of silver for coinage in the noncommunist world in 1975, according to Handy & Harman, was 35.0 million ounces, about 2.0 million ounces more than in 1974. Except for minor quantities used in 1971 in the minting of commemorative coins and in 1972 in the minting of silver dollars, silver had not been used in the production of Canadian coinage since 1968. On November 14, 1973 the Royal Canadian Mint struck the first new Olympic coin. It marked the beginning of production of coins containing 92.5 per cent silver to commemorate the Olympic Games to be held in 1976. The coins are of $5 and $10 face value and the total face value of all such coins to be issued may be up to $450 million, as provided by legislation contained in a special Act of Parliament given Royal Assent July 27, 1973. It was originally planned that the total amount of silver involved in minting the Olympic coins could be up to 58 million ounces and that the total number of coins issued could exceed 60 million. However, because of lower demand than anticipated, production plans were scaled down to some 44 million coins and this figure could be further reduced, depending on sales volume. The overall program consists of seven separate series of coins, with each series being comprised of four different coins, two of $5 face value and two of $10 face value, and with different designs for all 28 coins.

In 1974 the Royal Canadian Mint completed production of the first two series of the Olympic coins and began minting the third series. In 1975 the mint completed production of the third and fourth series of these coins and commenced minting the fifth series. According to figures published in the annual report of the Royal Canadian Mint, it produced and delivered to the Olympic Coin Programme in 1974, 3,981,140 pieces of the $5 coins and 3,949,878 pieces of the $10 coins, containing a total of about 8.57 million ounces of silver. For 1975 the corresponding figures were 3,970,000 pieces of the $5 coins and 4,952,433 pieces of the $10 coins, containing a total of approximately 10.00 million ounces of silver.

Construction of the new Winnipeg, Manitoba Division of the Royal Canadian Mint began late in 1972 and was not fully completed in 1975, but the Winnipeg plant began commercial production in March 1975. Operations at plants of the Royal Canadian Mint in Ottawa, Ontario, Hull, Quebec and Winnipeg, Manitoba were suspended on January 9, 1975 because of a labour

* *The Silver Market 1975,* compiled by Handy & Harman, a leading U.S. refiner and fabricator of precious metals and a large consumer of silver.



strike. A total of some 600 employees were involved in the strike, which did not end until March 3, 1975.

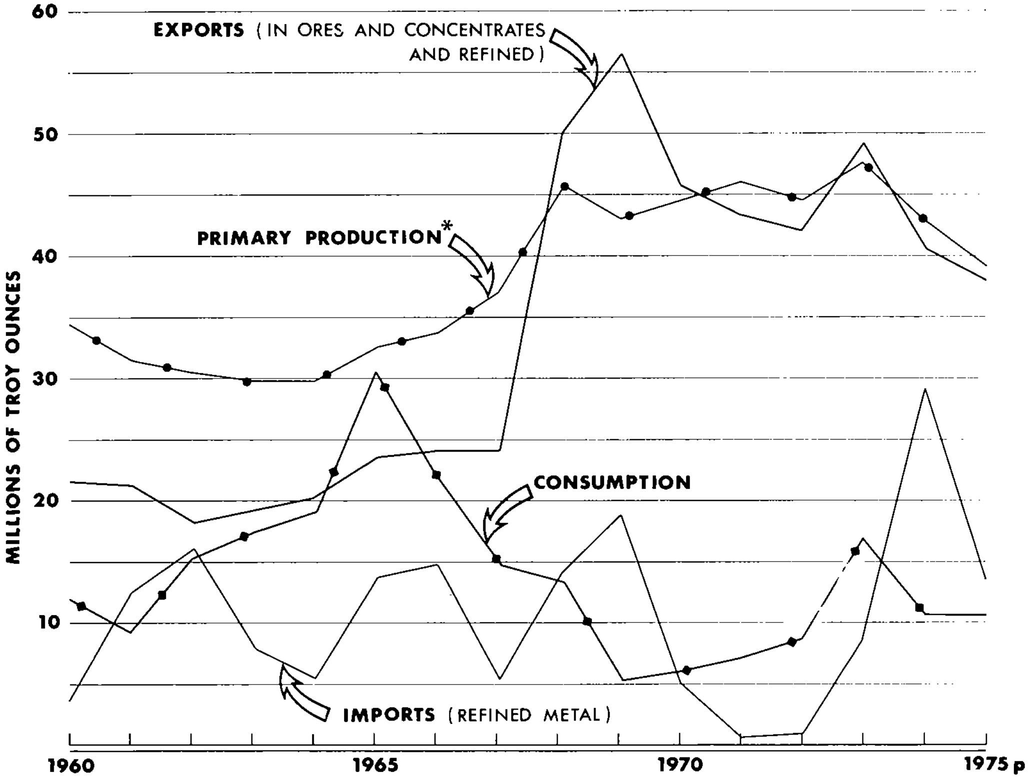
Johnson Matthey & Mallory Limited continued construction of a new $5 million precious metals refinery at Brampton, Ontario. The plant is scheduled to begin operations in May 1976. It will process scrap metal, sweeps, polishings, dross and other forms of precious metal scrap material, together with some primary materials such as placer gold and base bullion, primarily for recovery of the contained precious metals. In addition to its newly-installed smelting capacity, the refinery will continue to fire-refine precious metals and upgrade them electrolytically. Rated annual capacity of the new refinery will be 2,000,000 ounces of gold, 5,000,000 ounces of silver and 50,000 ounces of the platinum group metals. The company is affiliated with two world-wide organizations; Johnson, Matthey & Co. Limited of London, England, and P.R. Mallory Inc. of Indianapolis, Indiana, U.S.A.

Based on preliminary figures, Canada in 1975 lost its position as the world's largest mine producer of silver, a rank that it held from 1968 to 1974, with the exception of 1970. In 1975, the U.S.S.R. and Peru outranked Canada.

New production of silver in the United States increased slightly from 33.8 million ounces in 1974 to 34.9 million ounces in 1975. In the United States, the world's largest silver consumer, consumption for industrial uses and coinage was 157.7 and 2.7 million ounces, respectively, in 1975. The large deficit in requirements was again met by imports, demonetized coinage, secondary silver derived from discarded jewelry, silverware, films, etc., liquidation of speculative holdings and withdrawals from industrial and United States Treasury stocks. Most of the requirements for United States coinage were again obtained from Treasury stocks (Balance in Mint only) which, in the form of bullion, coin bars and coinage metal fund silver, declined during 1975 from 44.0 to 41.0 million ounces. On April 12, 1973, the U.S. Office of Emergency Preparedness (OEP) announced a revised stockpile objective of 21.7 million ounces of silver, 117.8 million ounces less than the

SILVER IN CANADA

MINERAL DEVELOPMENT SECTOR
DEPARTMENT OF ENERGY, MINES AND RESOURCES



* As reported by Statistics Canada and defined in Footnote 1 to Table 1.
p Preliminary

inventory and previous objective. The excess stockpiled silver thus became available for disposal but could not be sold without congressional approval. It was suggested that some 110.0 million ounces of the new stockpile excess of 117.8 million ounces be sold to U.S. industrial consumers and the remaining 7.8 million ounces be held for potential U.S. coinage requirements. The President's proposed stockpile disposal legislation, which included the release of 117.8 million ounces of silver, was introduced in Congress as bills H.R. 7153 and S. 1849 on April 18 and May 21, 1973, respectively. The bills were referred to a subcommittee of the House Armed Services Committee but, as of December 31, 1975, no action had been taken by the Congress on either of the bills. Therefore, the proposed stockpile reduction and the rate of its disposal have yet to be determined.

In 1975, the U.S. Mint continued the minting of Eisenhower dollar coins, containing 40 per cent silver, in special sets for numismatists. Production of these commemorative coins began in May 1971 and 150 million were authorized in a provision included in Public Law PL-91-607 which came into effect on December 31, 1970. The use of the metal in these special coins will not have any significant effect on the silver market as the United States Treasury Department, in 1970, had already set aside the silver (about 47 million ounces) that would be required. Part of these requirements resulted from a transfer of 25.5 million ounces from the strategic stockpile to the United States Mint. The transfer was made in the second quarter of 1971 and since then the silver inventory in the strategic stockpile has remained at 139,500,000 ounces.

Public Law PL-93-127 was enacted October 18, 1973 directing the Secretary of the U.S. Treasury to mint, prior to July 4, 1975, 45 million silver-clad alloy coins commemorating the Bicentennial of the American Revolution in 1976. The legislation also authorized the minting of not more than an additional 15 million of such coins if there is public demand for them. The coins contain 40 per cent silver and are minted in 25¢, 50¢ and $1.00 denominations. The total of 45 million coins require 8.07 million ounces of silver but, if the maximum quantity of 60 million coins are issued, the total amount of silver required will be 10.76 million ounces. The silver for these coins is supplied from current U.S. Treasury stocks.

On October 29, 1974 U.S. Public Law PL-93-463 was enacted. It is known as the Commodity Futures Trading Commission Act of 1974 and provides for Federal regulation of all commodities, including silver, traded on commodity exchanges. During 1975 the Commissioners, comprising the board of the Commodity Futures Trading Commission (CFTC), were appointed and assumed their regulatory responsibilities. Early actions of the Commission were directed at preventing irregular practices in the marketing of silver, especially those operations involving bullion bars sold as a possible hedge against inflation. The Commission also established regulations which require firms and individuals taking a major position in futures markets to file a daily trader report with the Commission. Later, the CFTC began considering regulations concerning bona-fide hedging and speculative limits.

Mexico and Peru held informal discussions about mid-1974 and again in the early part of 1975 concerning the establishment of the "Association of Silver Exporting Countries" to help maintain "equitable" price levels for the metal in world markets. Mexico and Peru together accounted for about 28 per cent of world mine production of silver in 1975 and are significant exporters. Up until late 1975 no firm action had been taken on the proposed association.

In February 1974, the government of India announced removal of the embargo against exports of silver bullion, sheets and plates, thus removing a longstanding ban on silver shipments abroad. It is thought that total Indian exports of silver amounted to about 27 million ounces in 1974 and 40 million ounces in 1975. Early in April 1976, however, the Indian government announced that for the fiscal year beginning April 1, 1976, it would limit silver exports to 1,400 metric tons (about 45 million troy ounces) a year. The amount of silver held in India, mainly by the Indian people, is unknown but believed to be very large, with "guesstimates" ranging all the way from one to five billion ounces. Given sufficient price inducement India will undoubtedly continue to be an important source of silver.

In the United States the Coeur mine near Wallace, in northern Idaho, has been leased by ASARCO Incorporated under an agreement with Coeur d'Alene Mines Corporation. About $10 million has been expended to equip this silver-copper property for production with a capacity to produce concentrates containing 2.2 million ounces of silver a year. Construction of ancillary surface facilities and a 450-ton-a-day concentrator and development of the mine were completed in 1975; and the property is scheduled to begin production in 1976. Press reports have stated that ore reserves were estimated at 834,000 tons* of probable ore averaging 25 ounces of silver a ton and one per cent copper, and 261,000 tons of inferred ore grading 25.9 ounces of silver a ton and 1.1 per cent copper.

Park City Ventures completed mine development work at the Ontario Mine near Park City, Utah. Construction of the company's 750-ton-a-day concentrator was also completed and it began operations in May 1975 with a capacity to produce concentrates containing 1.2 million ounces of silver annually. Park City Ventures is a joint venture managed by The Anaconda Company and owned 60 per cent by Anaconda and 40 per cent by ASARCO Incorporated.

ASARCO Incorporated began operations in the latter part of 1975 at its new copper refinery complex at Amarillo, Texas. Included in the new Amarillo facility is a precious metals plant which has a silver refinery scheduled to begin production about mid-1976. With an annual capacity of 60 million ounces of silver it is one of the world's largest and most modern silver refineries. The operation contains the most sophisticated production, materials handling and environmental equipment and the latest innovations in refinery design.

Mining operations began early in 1975 at the new Pueblo Viejo open-pit, gold-silver mine in the Dominican Republic. Construction of the 8,000-ton-a-day concentrator was completed and commercial production began on April 1, 1975. In addition to being the second largest gold mine in the Western Hemisphere, the mine will produce a significant quantity of silver. The processing plant has been designed to produce 350,000 ounces of gold and 1,500,000 ounces of silver a year in the form of Doré bullion. The bullion will be refined in Switzerland. At the end of 1975 oxide ore reserves were reported to be 26,544,068 metric tons averaging 4.32 grams (0.139 ounce) of gold and 23.3 grams (0.75 ounce) of silver a metric ton. Underlying the oxide ore is a sulphide zone containing an estimated 21,112,242 metric tons grading 3.57 grams (0.115 ounce) of gold and 26.1 grams (0.839 ounce) of silver a metric ton, 1.40 per cent zinc and 0.143 per cent copper.

Mexico, which has some lead-zinc mines that operate primarily for the extraction of silver, increased its

* The short ton of 2,000 pounds is used throughout unless otherwise stated.

mine output of the metal by about 1.5 million ounces in 1975. The Lampazos mine of Mineral Lampazos in the State of Sonora, Mexico, began operations early in 1975 at a rate of some 1.5 million ounces of silver a year. It marked the beginning of an expansion program under way at several mines in Mexico which could increase the country's mine output of silver to a rate of about 50 to 55 million ounces a year by late 1976.

Shaft sinking, underground mine development work and surface-plant construction continued in 1975 at the three silver-gold mines; Las Torres, Peregrina and Cebada, near the city of Guanajuato about 230 miles northwest of Mexico City. A central concentrator, to treat 2,000 metric tons of ore a day, was also under construction on a site adjacent to the Las Torres (Mother Lode) mine. Ore from underground development work at the three mines has been stockpiled on surface at the Las Torres mine and will be used as the initial mill feed. Mill operations were expected to begin early in 1976, at which time there should be some 100,000 metric tons of ore in the surface stockpile. The aggregate ore reserves of the three mines have been estimated at 4 million metric tons, grading an average of about 11.6 ounces of silver and 0.09 ounce of gold a metric ton after allowing for 15 per cent dilution. When full production is reached by the three mines, about 8 million ounces of silver and 50,000 ounces of gold are expected to be produced annually. The gold will be sold to the Bank of Mexico as provided by law, and the silver concentrates to the silver refinery of Industrias Penoles, S.A. The company operating the project is Compania Minera Las Torres, S.A., which is owned 30 per cent by Lacana Mining Corporation, 37 per cent by Compania Fresnillo, S.A., and 33 per cent by Industrias Penoles, S.A. Penoles is one of Mexico's largest private mining enterprises. Lacana Mining is a Canadian company with headquarters in Toronto — formerly Pure Silver Mines Limited. Total cost of bringing the three mines into production has been estimated at $39 million U.S. Negotiations continued with three Canadian banks which were expected to provide a substantial portion of the financing required to bring the properties into production. Late in 1975 it was reported that the Canadian banks had granted a $25 million loan to Compania Minera Las Torres, S.A. to assist the company in bringing its three mines into production. The loan is reportedly the largest ever given the Mexican private sector by Canadian financial institutions.

One of the major projects of M-I-M Holdings Limited, an Australian company in which ASARCO Incorporated holds a 49 per cent interest, is development of the McArthur River lead-zinc-silver deposit in the Northern Territory of Australia. Development work continued in 1975, and underground access to the orebodies and construction of a 55-ton-a-day pilot plant were completed. A study is also being made to determine the environmental impact of diverting the McArthur River in order to permit development of an open-pit mine. So far, at this sizeable deposit, an orebody has been proven that has an average thickness of 180 feet and contains 210 million tons of ore grading 9.5 per cent zinc, 4.1 per cent lead and 1.3 ounces of silver a ton. The physical characteristics of the ore, however, are such that only limited success has been achieved so far in devising a practical method of extracting the metals.

St. Joe Minerals Corporation and its co-venturer, Phelps Dodge Corporation (two United States companies), are considering production from their jointly owned copper-lead-zinc-silver property at Woodlawn in New South Wales, Australia. The final feasibility study has been completed and an environmental impact study has been published. It would take 18 to 24 months to bring this deposit into production. The deposit contains some 10 million tons grading 1.5 per cent copper, 3.0 per cent lead, 7.5 per cent zinc and 1.5 ounces of silver a ton. It could be mined by open-pit methods.

Silver prices were highly volatile again in 1975, mainly in response to speculative activity which in turn was fostered by monetary unrest and inflationary pressures. The price fluctuations were, however, not as extreme as those in 1974. Average prices for 1975 were somewhat lower than those for 1974 and no new highs were established. A generally-rising trend obtained from January until early August 1975, after which a downward drift prevailed, with year-end prices being close to those at the beginning of the year. Dominant factors behind silver price movements in 1975 were a significant decline in industrial consumption (almost 17 per cent during the year in the noncommunist world), pronounced speculative activity, a decline in visible stocks, the continuing shortfall between consumption and new production, and silver's use as a hedge against the monetary uncertainties and world-wide inflation that persisted in 1975.

On the New York Commodity Exchange, Inc. (Comex), one of the principal futures markets for contracts in silver in the United States, the volume of trading in silver in 1975 amounted to 2,902,315 contracts of 5,000 ounces each, compared with 608,860 contracts of 5,000 ounces each and 757,005 contracts of 10,000 ounces each traded in 1974. Effective September 27, 1974 Comex reduced the size of its silver futures contract from 10,000 to 5,000 ounces. The volume of silver traded on the Chicago Board of Trade in 1975 amounted to 1,952,703 contracts of 5,000 ounces each, compared with 1,462,195 contracts of the same size traded in 1974. The volume of silver traded on the Mid-America Commodity Exchange at Chicago in 1975 was 439,915 contracts of 1,000 ounces each, compared with 587,256 contracts of the same size in 1974. Silver traded on the London Metal Exchange was 492,370,000 ounces in 1975 compared with 641,910,000 ounces in 1974.

New York Commodity Exchange, Inc. silver stocks at the end of 1975 were 86.30 million ounces compared with 67.97 million ounces at December 31, 1974.

Table 3. World production[1] of silver, 1974-75

	1974^p	1975^e
	(troy ounces)	
U.S.S.R.[e3]	42,000,000	. .
Peru	41,000,000	41,000,000
Canada	42,809,000	39,101,000
Mexico	37,546,000	39,000,000
United States	33,762,000	34,100,000
Australia	21,615,000	. .
Japan	7,314,000	. .
Chile	6,646,000	. .
Poland[e]	6,000,000	. .
Bolivia[2]	5,385,000	. .
Yugoslavia	4,702,000	. .
Sweden	4,500,000[e]	. .
Honduras	3,661,000	. .
Spain	3,600,000[e]	. .
France	3,328,000[3]	. .
Morocco	3,137,000[4]	. .
East Germany[e]	3,000,000	. .
Republic of South Africa	2,994,000	. .
Argentina	2,400,000[e]	. .
Ireland	1,980,000	. .
Philippines	1,706,000	. .
Zaire	1,649,000	. .
Papua and New Guinea	1,628,000	. .
Territory of South-West Africa[5]	1,556,000[6]	. .
Italy	1,318,000	. .
South Korea (Republic of Korea)	1,291,000	. .
West Germany	1,228,000	. .
Romania[e]	1,100,000	. .
Czechoslovakia[e]	1,100,000	. .
Other countries	6,337,000	134,000,000
Total	296,292,000	287,201,000

Sources: Statistics Canada for Canada for 1974 and 1975. Other 1974 statistics from United States Department of the Interior, Preprint from the 1974 Bureau of Mines Minerals Yearbook. Other 1975 statistics from United States Department of the Interior, Bureau of Mines, Commodity Data Summaries 1976.
[1]Recoverable content of ores and concentrates produced unless otherwise noted. [2]Includes production by the State mining company, Corporacion Minera de Bolivia (COMIBOL), plus the exports of medium and small (private sector) mines. [3]Smelter and/or refinery production. [4]Partly estimated on the basis of silver content of lead ores exported [5]Data represent recoverable content of Tsumeb Corporation Ltd. concentrates as well as recovery from copper refinery sludges. [6]Includes estimate for Klein Aub Koper Maatskappy Ltd.
^{p}Preliminary; ^{e}Estimated; . . Not available.

Chicago Board of Trade silver in storage, at the end of 1975 and registered for delivery against futures' contracts, was 38.47 million ounces compared with 19.47 million ounces at December 31, 1974. Both figures for the Chicago Exchange are exclusive of some additional silver that may have been in stocks at such times, but not registered for future delivery. London Metal Exchange stocks at the end of 1975 were 17.83 million ounces compared with 11.97 million ounces at the end of 1974. United States industrial stocks* on December 31, 1975 were reported to be some 34.62 million ounces compared with about 49.33 million ounces at the end of 1974.

Outlook

Canada's primary production** of silver in 1976 is forecast to be 40 million ounces and is expected to range between 38 and 45 million ounces annually from 1977 to 1981.

World demand for silver declined again in 1975, mainly as a result of the continuing slowdown in economic activity in the major industrialized nations. With the world-wide economic recession showing signs of abating late in 1975, an increase in silver consumption is expected in 1976. This increase should be more pronounced in the United States than elsewhere because of a greater economic recovery expected in that country due to the fact that 1976 is an election year and also the year in which the United States celebrates its bicentennial. The long-term demand for silver for industrial uses is also expected to increase significantly.

Consumption will, however, continue to exceed primary production by a wide margin since mine output of silver is largely related to the production of the major base-metal ores. About 80 per cent (over 95 per cent in Canada) of the world's mine output of silver is derived as a byproduct or coproduct in the mining of such ores and, accordingly, the supply of newly-mined silver continues to depend more on the production of base-metal ores than on the demand for silver.

Because of large world stocks and a sluggish demand for the major base-metals, the cutbacks in production of these metals, which were initiated late in 1974, continued in 1975 and could persist in 1976. Such cutbacks have resulted in reduced mine output of silver. In the near-term, however, there should be no real shortage for industrial requirements. Sufficient quantities of secondary silver, speculative holdings, greater Indian exports and some hoarded silver coins will continue to find their way into the market. Because of higher prices and the increasing emphasis being placed on recycling by both government and industry, greater quantities of secondary silver are reaching the market. One significantly-increasing source of secondary silver results from microfilms being used to record data from the much larger X-ray negatives, thus making possible the immediate recycling of the silver used in the original films.

* Refiner, fabricator and dealer stocks.
** As defined in the footnote to Table 1.

Table 4. Principal silver (mine) producers in Canada, 1975 (and 1974)

Company and Location	Mill or Mine Capacity	Grade of Ore Produced				Ore Produced	Silver Contained in Concentrates Produced	Remarks
		Silver	Copper	Lead	Zinc			
	(tons of ore/day)	(oz/ton)	(%)	(%)	(%)	(tons)	(ounces)	
Newfoundland								
ASARCO Incorporated (Buchans Unit), Buchans	1,250 (1,250)	3.03 (3.25)	0.95 (1.01)	5.92 (6.28)	10.54 (11.24)	232,000 (264,000)	610,862 (741,438)	Ore production in 1975 12% lower than 1974 due to difficult mining conditions.
Consolidated Rambler Mines Limited, Ming mine, Baie Verte	1,200 (1,200)	0.57 (0.57)	3.20 (3.16)	— (—)	— (—)	224,562 (183,201)	108,494 (90,054)	Expected that new Boundary vertical shaft will be in full use early in 1976.
Nova Scotia								
Dresser Minerals, Division of Dresser Industries, Inc. Walton	— (—)	— (. .)	— (. .)	— (. .)	— (. .)	— (. .)	— (25,190)	Due to depletion, mining and milling of sulphide ore reserves ceased in 1973. The 25,190 oz. silver was contained in concentrates shipped from stockpile in 1974.
New Brunswick								
Anaconda Canada, Limited, Caribou mine, Restigouche Co.	— (700)	— (2.30)	— (3.76)	— (1.86)	— (3.95)	— (163,432)	— (84,738)	Operations ceased late 1974 because copper ore reserves exhausted.
Brunswick Mining and Smelting Corporation Limited, Nos. 12 and 6 mines, Bathurst[1]	10,000 (10,000)	2.33 (2.32)	0.40 (0.38)	2.95 (2.96)	7.11 (6.70)	3,427,239 (2,607,965)	5,386,000[e] (4,994,800)[e]	Ore production from No. 6 open pit will cease in 1977.
Heath Steele Mines Limited, Newcastle	3,100 (3,100)	1.73 (1.98)	1.03 (1.04)	1.54 (1.72)	3.99 (4.39)	1,089,443 (1,085,495)	1,026,845 (1,184,840)	Preparing for rated ore production of 4,000 tons a day to begin about early January 1977.
Nigadoo River Mines Limited, Bathurst	1,000 (1,000)	3.44 (3.74)	0.25 (0.33)	2.55 (2.53)	2.69 (2.74)	255,078 (205,691)	683,789 (619,353)	Total ore reserves at August 31, 1975 were 856,946 tons averaging 0.19% copper, 3.05% lead, 3.13% zinc, and 3.61 ounces silver a ton.

Quebec								
Campbell Chibougamau Mines Ltd., Main Mine, Cedar Bay, Henderson, Grandroy and Gwillim mines, Chibougamau	4,000 (4,000)	0.229 (0.22)	1.31 (1.03)	– (–)	– (–)	219,543 (960,552)	22,357 (110,472)	On May 5, 1975, mining operations were suspended, and mines put on a maintenance basis.
Clinton Copper Mines Ltd., Notre-Dame des Bois	ore custom-milled	0.876 (0.951)	2.59 (2.64)	0.47 (0.48)	2.49 (2.50)	73,535 (52,656)	49,759 (42,363)	Mining operations were terminated in June 1975.
Falconbridge Copper Limited, Lake Dufault Division, Millenbach and Norbec mines, Noranda	1,550 (1,500)	1.12 (0.99)	2.50 (2.38)	– (–)	3.35 (3.54)	560,775 (553,187)	418,700 (434,065)	Started shaft sinking for a potential new underground mine.
Falconbridge Copper Limited, Opemiska Division, Perry and Springer mines, Chapais	3,000 (3,000)	0.33 (0.32)	2.02 (1.85)	– (–)	– (–)	952,000 (927,059)	265,000 (253,144)	In 1975 the Cooke shaft was completed to a depth of 1,985 feet and 10 stations were established.
Gaspe Copper Mines, Limited, Needle Mountain and Copper Moutain mines, Murdochville	33,750 (33,750)	0.12 (0.05)	0.52 (0.61)	– (–)	– (–)	10,993,105 (10,630,690)	798,685 (620,733)	Production at rated capacity not obtained.
Madeleine Mines Ltd., Ste-Anne-des-Monts	2,500 (2,500)	0.20 (0.22)	1.148 (1.27)	– (–)	– (–)	908,225 (804,390)	174,997 (178,276)	Plans to continue underground diamond drilling.
Manitou-Barvue Mines Limited, Golden Manitou mine[2], Val d'Or	1,600 (1,600)	2.46 (2.58)	. . (.)	0.30 (0.35)	1.81 (2.20)	244,955 (225,303)	307,096 (404,810)	In 1975, mine development fell short of that forecast due to shortage of experienced labour.
Mattagami Lake Mines Limited, Matagami	3,850 (3,850)	0.86 (0.88)	0.62 (0.62)	– (–)	7.3 (7.5)	1,285,703 (1,406,265)	471,402 (453,253)	Shaft sinking started on Lyon Lake property.
Noranda Mines Limited, Horne Division, Noranda	2,100 (2,200)	. . (0.59)	4.42 (2.8)	– (–)	– (–)	606,840[3] (390,000)	104,375 (138,083)	Ore reserves at Horne mine will be exhausted in 1976.
Normetal Mines Limited, Normetal	1,000 (838)	1.28 (1.1)	0.58 (0.97)	– (–)	5.86 (4.58)	82,150 (250,492)	57,131 (166,000)[e]	Operations suspended April 30, 1975 due to exhaustion of ore reserves.
Orchan Mines Limited, Matagami	1,900 (1,900)	0.48 (0.50)	1.19 (1.18)	. . (0.05)	4.65 (4.78)	421,805 (364,030)	97,000[e] (86,000)[e]	Shaft sinking completed at Norita Division and mine development in progress.
Patino Mines (Quebec) Limited, Chibougamau	1,700 (2,800)	0.248 (0.200)	1.67 (1.56)	– (–)	– (–)	439,515 (859,332)	77,249 (123,187)	Operations suspended November 16, 1974 to April 16, 1975 by a strike.

Table 4. (cont'd)

Company and Location	Mill or Mine Capacity	Grade of Ore Produced: Silver	Grade of Ore Produced: Copper	Grade of Ore Produced: Lead	Grade of Ore Produced: Zinc	Ore Produced	Silver Contained in Concentrates Produced	Remarks
	(tons of ore/day)	(oz/ton)	(%)	(%)	(%)	(tons)	(ounces)	
Quebec (cont'd)								
Sullivan Mining Group Ltd., Stratford Centre	1,400 (1,500)							
Cupra Division		0.972 (1.112)	2.24 (2.49)	0.47 (0.59)	4.12 (4.78)	56,058 (87,474)	48,042^e (83,725)	Ore reserves at August 31, 1975 were 95,000 tons averaging 2.46% copper, 0.51% lead, 3.80% zinc, and 1.022 ounces of silver a ton.
D'Estrie Mining Company Ltd.		1.116 (1.155)	2.57 (2.56)	0.54 (0.61)	2.12 (2.72)	180,094 (162,081)	166,758^e (160,618)^e	Diamond drilling program carried out from bottom level to explore downward extension of mineral deposit.
Ontario								
Agnico-Eagle Mines Limited, Cobalt district	400 (400)	18.65 (. .)	. . (. .)	— (—)	— (—)	17,410 (38,718)[a]	307,313 (467,105)	Extensive exploration program planned for 1976.
Canadaka Mines Limited, Cobalt district	150 (150)	. . (. .)	. . (. .)	. . (. .)	. . (. .)	10,920 (. .)	64,908 (. .)	Concentrator burned down May, 1975 and began construction of new 600-ton-a-day concentrator.
Falconbridge Copper Limited, Sturgeon Lake Joint Venture, Sturgeon Lake (formerly listed as Sturgeon Lake Mines Limited)	1,200 (1,200)	5.31 (4.58)	2.78 (2.05)	1.17 (1.09)	9.07 (7.59)	376,682 (82,592)	1,096,993 (133,200)	In 1975 spent about $850,000 on mill expansion.
Falconbridge Nickel Mines Limited, Ontario mines, Sudbury district	12,300 (12,100)	. . (. .)	. . (. .)	— (—)	— (—)	3,012,005 (4,337,000)	. . (. .)	2,300 ton-a-day expansion in total concentrator capacity nearing completion.
Mattabi Mines Limited, Sturgeon Lake	3,000 (3,000)	3.23 (4.31)	0.97 (0.91)	0.70 (0.91)	7.34 (8.81)	1,074,923 (1,138,965)	2,251,441^e (3,574,116)^e	Development for underground mining suspended after completing the 3500-foot access decline to planned location of main haulage level.

Table 4. (cont'd)

Noranda Mines Limited, Geco Division, Manitouwadge	5,000 (5,000)	1.44 (1.56)	1.84 (1.72)	. . (0.20)	3.54 (4.72)	1,599,333 (1,826,704)	1,811,479 (2,259,614)[e]	In 1975, underground operations still hampered by shortage of miners.
Selco Mining Corporation Limited, South Bay Division, Uchi Lake area	500 (500)	2.73 (3.0)	1.82 (2.0)	. . (.)	11.18 (13.0)	168,334 (195,000)	392,067 (515,000)[e]	Shaft deepening completed to depth of 1,817 feet below collar.
Teck Corporation Limited, Silverfields Division, Cobalt district	275 (270)	9.7 (9.2)	0 4 (0.4)[e]	— (—)	— (—)	48,411 (87,891)	471,050 (850,648)	Operations suspended July 12, 1975 by a strike which was still in effect at year-end.
Texasgulf Canada Ltd., Kidd Creek mine, Timmins, (formerly Ecstall Mining Limited)	10,000 (10,000)	3.10 (3.17)	1.71 (1.75)	0.25 (0.30)	8.20 (9.20)	3,630,224 (3,723,865)	9,076,638 (9,267,000)	Plans to expand underground mine, build a copper smelter and refinery and increase mill capacity by 33%.
The International Nickel Company of Canada, Limited, Sudbury and Shebandowan, Ont., and Thompson, Man.	85,900 (85,900)	. . (.)	. . (.)	— (—)	— (—)	21,200,000 (22,000,000)	1,900,000[5] (1,910,000)[5]	Began development of new Levack East mine in Sudbury area.
Willroy Mines Limited, Willroy and Willecho mines, Manitouwadge	1,400 (1,700)	1.56 (1.37)	0.42 (0.42)	0.22 (0.23)	3.82 (3.06)	327,353 (394,154)	346,092 (315,000)[e]	Developed No. 1 zone orebody at Willecho shaft on 550-foot level.
Manitoba-Saskatchewan								
Hudson Bay Mining and Smelting Co., Limited, Flin Flon and Snow Lake districts	8,500 (8,500)	0.60 (0.63)	2.4 (2.34)	0.2 (0.12)	3.0 (3.22)	1,470,157 (1,574,948)	647,331 (771,862)	Continued development of Centennial mine.
Sherritt Gordon Mines Limited Fox mine, Lynn Lake	2,840 (3,000)	. . (0.33)	1.735 (2.104)	— (—)	1.814 (1.98)	1,007,183 (1,008,111)	232,896 (330,469)	Mine deepened to 2200 level.
Ruttan mine, Ruttan	10,000 (10,000)	. . (0.20)	0.96 (1.065)	— (—)	1.90 (1.676)	3,340,794 (3,358,257)	338,178 (670,144)	Plans detailed diamond drilling for proposed underground development.
The International Nickel Company of Canada, Limited, Thompson, Man.	(included with this company's listing for Ontario)							
British Columbia								
Bethlehem Copper Corporation, Highland Valley	20,000 (16,000)	0.02 (.)	0.474 (0.505)	— (—)	— (—)	6,464,539 (6,346,402)	151,899 (178,120)	Ore remaining in the Huestis, Iona and Jersey extension will provide mill feed, at present rate of production, for about 8 years.

Table 4. (cont'd)

Company and Location	Mill or Mine Capacity	Grade of Ore Produced: Silver	Copper	Lead	Zinc	Ore Produced	Silver Contained in Concentrates Produced	Remarks
	(tons of ore/day)	(oz/ton)	(%)	(%)	(%)	(tons)	(ounces)	
British Columbia (cont'd)								
Brenda Mines Ltd., Peachland	24,000 (24,000)	. . (. .)	0.188 (0.186)	– (–)	– (–)	10,048,545 (9,549,588)	253,111 (230,013)	Studies concluded in 1975 indicated that 10% haulage ramps will permit mining of two additional levels in pit bottom.
Cominco Ltd., Sullivan mine, Kimberley	8,000 (10,000)	1.27 (1.41)	. . (. .)	3.85 (4.11)	4.16 (4.49)	2,207,848 (1,416,489)	2,351,034 (1,653,334)	Plan to convert from slusher mining to predominantly trackless drawpoint mining over next 5 years.
Consolidated Columbia River Mines Ltd., Ruth-Vermont mine, Golden	500 (500)	. . (–)	. . (–)	. . (–)	. . (–)	11,308 (–)	23,348 (–)	Developed Pine Tree vein.
Dankoe Mines Ltd., Keremeos	450 (400)	13.0 (10.0)	. . (. .)	4.0 (. .)	2.0 (. .)	19,747 (24,351)	325,266 (218,424)	July 31, 1975, company ceased milling its own ore and began custom milling Dusty Mac Mine's ore.
Dusty Mac Mines Ltd., Keremeos	ore custom-milled	4.23 (–)	. . (–)	. . (–)	– (–)	44,027 (–)	138,033 (–)	Known ore expected to be mined out early in 1976. Percussion drilling in progress to find new ore.
Gibraltar Mines Ltd., McLeese Lake, Cariboo district	40,000 (40,000)	. . (. .)	0.431 (0.40)	– (–)	– (–)	11,450,000 (13,397,264)	. . (. .)	Plans to begin mining of the Pollyanna pit in second quarter of 1976.
Granby Mining Corporation, Phoenix Copper Division, Greenwood	2,800 (2,750)	0.175 (0.134)	0.487 (0.446)	– (–)	– (–)	1,086,747 (1,012,426)	117,500 (85,204)	As of May 1, 1975, the mining operation was reduced from 3 shifts per day to one.
Granduc Operating Company, Stewart	7,500 (8,000)	. . (0.216)	1.20 (1.23)	– (–)	– (–)	1,653,000 (2,708,731)	340,278 (584,265)	Production and work force cut back by 50%.
Granisle Copper Limited, Babine Lake, (formerly listed as The Granby Mining Company Limited, Granisle mine)	13,000 (13,000)	0.038 (. .)	0.436 (0.446)	– (–)	– (–)	4,932,982 (4,780,857)	180,390 (176,035)	Projected capital expenditures for fiscal year ending September 30, 1976 are estimated at $2,300,000.

Table 4. (cont'd)

British Columbia (concl'd)								
Kam-Kotia Mines Limited, Silmonac mine, Slocan district	120 (140)	17.48 (12.76)	. . (.)	5.66 (3.28)	4.82 (4.16)	12,045 (12,034)	200,268 (150,214)	Plans limited development and diamond drilling.
Lornex Mining Corporation Ltd., Highland Valley	45,000 (45,000)	. . (.)	0.495 (0.457)	— (—)	— (—)	12,893,157 (16,445,460)	376,227 (515,684)^e	Strict cost control programs continue to be pursued aggressively.
Placid Oil Company, Bull River mine, Cranbrook	— (750)	— (.)	— (.)	— (—)	— (—)	— (100,904)	— (42,560)	On June 10, 1974, closed down for an indefinite period.
Reeves MacDonald Mines Limited, Annex mine, Remac	1,000 (1,000)	0.60 (0.64)	. . (.)	0.58 (1.18)	3.07 (3.84)	35,507 (195,565)	9,544 (84,221)^e	Mine ceased operations end of first quarter 1975.
Similkameen Mining Company Limited, Ingerbelle Pit, Princeton	15,000 (15,000)	0.0212 (.)	0.46 (0.48)	— (—)	— (—)	4,072,000 (5,086,000)	86,408 (117,650)	Expanding mill from 15,000 to 22,000 tons of ore a day.
Teck Corporation Limited, Beaverdell mine, Beaverdell	110 (120)	9.30 (9.06)	. . (0.003)	0.38 (0.41)	0.39 (0.52)	38,469 (37,184)	357,881 (336,860)	Plan routine diamond drilling.
Utah Mines Ltd., Island Copper mine, Coal Harbour, Vancouver Island	38,000 (38,000)	. . (.)	0.48 (0.47)	— (—)	— (—)	13,300,000 (11,200,000)	306,000 (229,200)	Ore production in 1975 was significantly greater than in strike-impacted 1974.
Wesfrob Mines Limited, Tasu Harbour, Queen Charlotte Islands	5,800 (5,800)	. . (.)	0.212 (0.282)	— (—)	— (—)	1,788,383 (939,313)	55,919 (80,804)	Developed Delta Blue Jay underground orebody.
Western Mines Limited, Buttle Lake, Vancouver Island	1,100 (1,100)	4.49 (4.52)	1.12 (1.28)	1.42 (1.48)	7.59 (8.05)	287,393 (297,290)	1,186,628 (1,198,929)^e	Plans routine exploration and development work.
Northwest Territories								
Echo Bay Mines Ltd., Port Radium	150 (150)	. . (104.29)	. . (0.99)	— (—)	— (—)	31,251 (20,768)	771,332 (2,120,038)	Dewatered old Eldorado workings to 7th level.
Terra Mining and Exploration Limited, Camsell River area	175 (175)	. . (24.02)	. . (0.30)	— (—)	— (—)	42,881 (45,684)	1,320,724 (1,093,919)	Late in 1975, promising new 9B vein discovered.
Yukon Territory								
Cyprus Anvil Mining Corporation, Faro	10,000 (10,000)	. . (.)	. . (.)	4.03 (4.51)	5.41 (5.60)	3,225,223 (2,925,000)	3,011,274^e (3,059,801)^e	Major capital expenditures will probably be incurred in 1976 to provide equipment to sustain operations at full capacity.

Table 4. (concl'd)

Company and Location	Mill or Mine Capacity	Grade of Ore Produced: Silver	Copper	Lead	Zinc	Ore Produced	Silver Contained in Concentrates Produced	Remarks
	(tons of ore/day)	(oz/ton)	(%)	(%)	(%)	(tons)	(ounces)	
Yukon Territory (concl'd)								
United Keno Hill Mines Limited, Husky, Elsa, Keno, Dixie and Townsite mines, Elsa	500 (500)	34.96 (37.73)	. . (.)	4.03 (4.22)	1.15 (1.15)	90,860 (93,232)	3,010,750[e] (3,353,242)[e]	Exploration work continuing.
Whitehorse Copper Mines Ltd., Whitehorse	2,400 (2,000)	. . (0.346)	1.52 (1.84)	— (—)	— (—)	738,062 (618,000)	217,400 (212,201)	Plans continued exploration in region of Whitehorse Copper belt.

Source: Company reports and technical press.
[1]All statistical data, including mill capacity, represent combined results for Nos. 12 and 6 mines and mills. [2]Grade and production statistics do not include 160,900 tons of copper ore custom-milled in a separate circuit in 1974 and a total of 154,958 tons of combined copper and zinc ores custom-milled in separate circuits in 1975. [3]Figure includes 282,259 tons of underground ore and 324,581 tons of slag. [4]Figure includes 9,941 tons of ore from Trout Lake No. 3 shaft, from which were derived 416,399 ounces of silver, and supplementary feed of 28,777 tons from low grade tailings and surface rock dumps from which were derived 50,706 ounces of silver. [5]Silver delivered to markets.
[e]Estimated; — Nil; . . Not available.

Table 5. Prospective[1] silver producing mines in Canada

Company and Location	Year Production Expected	Planned Mill or Mine Capacity	Reported Ore Reserves	Average Grade of Ore: Silver	Copper	Lead	Zinc	Remarks
		(tons ore/day)	(short tons)	(oz/ton)	(%)	(%)	(%)	
Quebec								
Falconbridge Copper Limited, Opemiska Division, Cooke mine, Chapais	. .	300	555,000	. .	1.46	—	. .	Shaft sinking completed to depth of 1,985 feet and mine development in progress. Ore reserves also contain 0.3 ounce of gold a ton.
Lemoine Mines Limited, Chibougamau	1976	400	625,000[2]	2.70	4.5	—	10.8	Ore reserves contain 0.138 ounce gold a ton. In 1975, orebody developed and prepared for underground mining, mill constructed, and mill tune-up begun at year-end.

Quebec (concl'd)								
Manitou-Barvue Mines Limited, Barvue zinc-silver property, Barraute township	. .	1,000	4,000,000	1.2	. .	. .	3.50	Late in 1975, Manitou-Barvue, Orchan Mines Limited and Noranda Mines Limited finalized joint agreement to bring property into production.
Orchan Mines Limited, Norita mine, Matagami	1976	900	1,965,307[3]	0.9	0.6	—	6.4	Shaft sinking completed and mine development in progress. Full production scheduled for mid-1976, with ore to be processed at Orchan mill.
Ontario								
Mattagami Lake Mines Limited, Lyon Lake orebodies, Sturgeon Lake	1978	1,000	4,029,500	3.30	1.15	0.63	6.66	Installation of permanent mining plant completed and at year-end shaft sinking advanced to depth of 688 feet.
Manitoba-Saskatchewan								
Hudson Bay Mining and Smelting Co., Limited, Flin Flon district								
Centennial mine	. .	. .	1,460,000		2.06	. .	2.6	Main shaft sunk 1,411 feet; at end of 1975 lateral development began on most levels.
Westarm mine	. .	. .	710,000	. .	4.63	. .	0.6	Shaft sinking began June 1, 1975 and by year-end it had reached depth of 1,457 feet.
British Columbia								
Northair Mines Ltd., Brandywine Falls mine, Alta Lake	1976	300	459,200	3.49^e	0.33^e	2.28^e	3.09^e	Ore reserves also reported to contain 0.46 ounce of gold a ton.
Northwest Territories								
Nanisivik Mines Ltd., Strathcona Sound, Baffin Island	1977	1,500	7,000,000	1.77	. .	1.4	14.1	Construction of mine and concentrator began in 1974 and production could commence late in 1976.

[1]Those mines which have announced production plans. [2]After providing for 15 per cent dilution. [3]Drill indicated reserves, including allowance for dilution.
^{e}Estimated; — Nil; . . Not available.

Among the bearish factors influencing the silver market are the 118 million ounces of surplus silver in the United States government's strategic stockpile, and increasing imports from India. Bullish elements include the big deficiency between new production and consumption and a projected increase in industrial demand as the western economies pick up steam. Depressing factors, insofar as mine output of silver is concerned, are the lower base-metal prices, high inflation, rising operating costs and, according to the industry, the onerous mineral taxes that are plaguing the metal mining industry. As a result of this adverse economic climate, several base-metal mines have reduced output and curtailed exploration and development work. Such measures do not augur well for the future supply of silver. The profitability as well as the ability of the metal mining industry to explore for and develop new or alternative sources of raw material is being impaired; and, even worse, the industry's ability to replace existing facilities and ore reserves is being severely restricted.

It is expected that silver prices will be erratic again in 1976, although displaying an upward trend. The price fluctuations will not be entirely governed by the law of supply and demand but will continue to be affected by the whims and actions of the speculators. In the short-term there is now some hope for a lessening of the excesses that have obtained in recent years, since the basic problems of economic conflict and monetary uncertainty are receiving greater international attention. A good omen is that world-wide inflation is showing signs of abating. The price trend from 1976 to 1980 is expected to be upward.

Canadian developments

Atlantic Provinces. Silver production in the Atlantic provinces was somewhat higher in 1975 than in the previous year, mainly because of greater byproduct output by the silver-base-metal mines of Brunswick Mining and Smelting Corporation Limited near Bathurst, New Brunswick. In 1974 operations were suspended for 66 days at the Brunswick property because of a labour strike. The project to expand Brunswick's No. 12 mine production to 11,000 tons of ore a day in 1979, compared to the present maximum hoisting capability of 7,000 tons a day, is on schedule. Cost escalations, however, have raised the estimated cost of the project from $48.1 million to $51 million, of which $24.7 million had been spent or committed as at December 31, 1975. The project includes sinking of the new No. 3 shaft to a depth of 4,300 feet from surface. A decline has been driven below the No. 6 open pit mine to explore and develop for mining the downward extension of that orebody. Operations at the No. 6 open-pit orebody will cease in 1977.

As a result of underground exploration work in 1975 at the Brunswick property, zinc-lead ore reserves were increased substantially, mainly at the No. 12 mine. At December 31, 1975 proven and probable zinc-lead ore reserves, after dilution, at the No. 12 mine totalled 98,173,000 tons grading 0.30 per cent copper, 3.79 per cent lead, 9.22 per cent zinc, and 2.79 ounces of silver a ton. At December 31, 1975 proven zinc-lead ore reserves at the No. 6 mine (in the open-pit and underground) were 2,654,000 tons averaging 0.34 per cent copper, 2.23 per cent lead, 6.27 per cent zinc, and 2.31 ounces of silver a ton. Proven and probable copper ore reserves at the No. 12 mine at the end of 1975 totalled 14,094,000 tons grading 1.11 per cent copper, 0.45 per cent lead, 1.27 per cent zinc, and 1.03 ounces of silver a ton.

Nigadoo River Mines Limited completed, in 1975, its first full year of operations since resuming production early in January 1974 at its zinc-lead-copper-silver property near Bathurst. The property had previously been idle since January 1972 when mining and milling operations were suspended following economic and labour problems.

The mining and exploration sectors in New Brunswick continued, in 1975, to be among the most buoyant of any of the Canadian provinces, partly because New Brunswick's mineral taxation policies have encouraged the maximum amount of exploration, development and processing by the private sector of the mining industry.

Quebec. Silver output in Quebec, derived mostly from base-metal ores, was somewhat higher in 1975 than in 1974.

Mining operations ceased April 30, 1975 at the zinc-copper-silver property of Normetal Mines Limited at Normetal, Quebec, because of the exhaustion of ore reserves. Since production began in September 1937 a total of 14,690,000 ounces of silver had been recovered.

Lemoine Mines Limited, incorporated early in 1974, completed underground development work in 1975 at its copper-zinc-gold-silver property in Lemoine township southeast of Chibougamau, discovered late in 1973 by Patino Mines (Quebec) Limited. The ore consists of a nearly-massive sulphide lens which has been drilled to a depth of 1,000 feet from surface. Shaft sinking was completed to a depth of 1,090 feet and construction of a concentrator of 400 tons-a-day capacity and other surface facilities were completed before the end of 1975. Mill tune-up operations began in mid-November 1975. Both Lemoine Mines Limited and Patino Mines (Quebec) Limited are wholly-owned subsidiaries of Patino, N.V.

By mid-1975 shaft sinking was completed to a depth of 1,682 feet at the Norita Division's zinc-copper-silver property. Seven level stations were established and excavation completed for the underground crusher. The Norita mine is operated and controlled by Orchan Mines Limited and is about eight miles northeast of the main Orchan mine in the Matagami Lake area of northwestern Quebec. Production at a rate of 900 tons of ore a day was expected to begin early in 1976, with the ore to be processed at the nearby Orchan concentrator.

In December 1975 Noranda Mines Limited and Orchan Mines Limited exercised their option to acquire the former producing zinc-silver property of Manitou-Barvue Mines Limited in Barraute township in northwestern Quebec. Before the end of 1974, the Barvue open-pit had been completely de-watered. It was expected that the property would be brought into production as soon as market conditions warrant. When production ceased at the property in 1957 the mineralized deposit contained 4.0 million tons grading 3.5 per cent zinc and 1.2 ounces of silver a ton to the 600-foot level.

Early in 1976 it was announced that Orchan Mines Limited had acquired from Phelps Dodge Corporation of Canada, Limited the latter's zinc-copper-silver deposit in La Gauchetiere township in northwestern Quebec, about 25 miles west of the main Orchan minesite. The property is to be developed by a decline and a new 1,800-foot shaft, and is expected to be brought into production by mid-1978 at a rate of 800 tons of ore a day at a cost of some $8 million. The ore will be processed at the Orchan concentrator. Diamond drilling on the property by Phelps Dodge indicated a mineral deposit which has not yet been limited at depth and which is estimated to contain some 1,545,000 tons averaging 4.5 per cent zinc, 0.9 per cent copper, and 0.5 ounce of silver a ton, including allowance for dilution.

By the end of 1975 surface plant construction was substantially complete at the new Corbet copper-zinc-silver-gold mine of Falconbridge Copper Limited, about 7,000 feet southwest of the company's Millenbach mine near Noranda, Quebec. Expenditures to the end of 1975 on the project amounted to $4 million and the planned preproduction program for 1976 is estimated to cost $2.9 million.

In August 1974, it was announced that Selco Mining Corporation Limited (in which Selection Trust Limited of London, England has a 94 per cent interest) and Pickands Mather & Co. of Cleveland, Ohio, had made a major zinc-copper-silver-gold discovery in the Brouillan township area of northwestern Quebec. Selco and Pickands Mather are equal partners in the property, known as the "Detour Project", although it is managed by Selco. Work to date had revealed three zones of interest, designated the A-1, A-2 and B zones. A preliminary estimate based on the results of diamond drilling from the A-1 zone has indicated the presence of a near-surface deposit of 35.4 million tons with an average diluted grade of 0.39 per cent copper, 2.30 per cent zinc, 1.04 ounces of silver and 0.009 ounce of gold a ton. In 1975 exploration drilling was stopped on the three zones since sufficient drilling had been done to undertake preliminary mining and metallurgical studies, with the objective of examining the feasibility of commercial operation. Early in 1976 the company announced that it is going ahead with a $13 million underground development program on the Detour property. The program will run into mid-1978 and include shaft sinking.

At the "Lessard Prospect" in north-central Quebec a joint venture in which Selco Mining Corporation Limited holds an interest of 72 per cent, has outlined a potential mineral reserve of the order of 1.5 million tons grading 1.73 per cent copper, 2.96 per cent zinc, and 1.10 ounces of silver and 0.019 ounce of gold a ton. The company considers that additional tonnage will have to be found before a viable mining operation can be contemplated and, accordingly, a further drilling programme to this end is under consideration. The remaining 28 per cent interest in the Lessard Prospect is held by Muscocho Explorations Limited.

Ontario. Ontario was the leading silver-producing province in 1975, with its output accounting for 37 per cent of Canadian mine production. The leading producer was Texasgulf Canada Ltd., which recovered over 9 million ounces in copper, lead and zinc concentrates at its Kidd Creek property, the largest single mine producer of silver in Canada and probably the world.

In a 50-50 joint venture with the Canadian subsidiary of Pechiney Ugine Kuhlmann Development, Inc., of Paris, France, St. Joseph Explorations Limited, a wholly-owned subsidiary of St. Joe Minerals Corporation of New York, N.Y., continued construction of a silver treatment plant and refinery at Cobalt, Ontario. The operating company is known as Canadian Smelting & Refining (1974) Limited. Commercial production was expected to begin at the plant early in 1976. The plant will be a hydrometallurgical operation using an acid wash-cyanidation process, and it is expected it will be able to process any ores and concentrates produced in the Cobalt area, including lower-grade flotation concentrates. The plant is also expected to treat similar type concentrates, or silver containing precipitates, residues or secondary materials, produced elsewhere. The major product will be refined silver, with the annual capacity being up to 6 million ounces of silver, depending on the nature of the materials processed. Grade of the refined silver is expected to be 99.95+ per cent silver. Among the byproducts expected to be produced would be precipitates, residues or other materials containing cobalt, nickel, copper, lead and antimony. When the plant becomes operational it will give the Cobalt area silver producers the opportunity of having their ores and concentrates processed locally. Since the Refinery Division of Kam-Kotia Mines Limited suspended operations in February 1972 at its silver refinery at Cobalt, the mine producers in the area have had to ship their products to other Canadian or foreign plants for treatment.

At the Kidd Creek property of Texasgulf Canada Ltd. near Timmins, Ontario, work continued on the $300-$350 million expansion program begun in 1974. Included in the program is an increase in mine production from 3.6 to 5.0 million tons of ore a year, installation of the fourth 3,500-ton-a-day circuit in the concentrator, and construction of a 130,000-ton-a-year copper smelter and refinery complex at the Kidd Creek metallurgical site. Development of the No. 2 underground mine is on schedule and it is being opened by a 25-foot-diameter shaft being sunk to a depth of some 5,200 feet from surface. Mining of the open-pit is scheduled for completion at the end of 1976. Start-up of the fourth 3,500-ton-a-day circuit in the concentrator is scheduled for late 1978. Included in the new refinery complex is a silver refinery. Construction of the copper smelter and refinery was expected to begin in the spring of 1976 with start-up scheduled for late 1978. The silver refinery could come on stream as much as two years later, although there is a possibility it will open simultaneously with the copper refinery. It is anticipated that the silver refinery will have an annual capacity of 10-12 million ounces of refined silver. This capacity should be sufficient to process the silver content of the copper concentrates at maximum planned production.

At December 31, 1975, ore reserves above the 2,800-foot level at Texasgulf's Kidd Creek mine were estimated at 92 million tons. Of that total, 86 million tons were classified as proven and probable ore containing an estimated 2.70 per cent copper, 0.21 per cent lead, 5.92 per cent zinc and 2.31 ounces of silver a ton. The remaining 6 million tons were classified as inferred ore. Drilling from the 2,800-foot level has indicated ore to at least the 5,000-foot level and the ultimate depth and dimensions of the orebody are still unknown.

In 1974, Mattagami Lake Mines Limited decided to bring into production its Lyon Lake property about five miles to the east of the Mattabi mine in the Sturgeon Lake area of northwestern Ontario. Installation of the surface plant was completed in 1975 and at year-end shaft sinking had advanced to a depth of 688 feet from surface. It is planned to complete in 1976 the shaft sinking, ore passes and loading facilities, and to begin lateral development. Production is scheduled to begin late in 1977 or early 1978. Ore reserves are 4,029,500 tons grading 1.15 per cent copper, 0.63 per cent lead, 6.6 per cent zinc and 3.30 ounces of silver a ton.

In the Cobalt area of northern Ontario less than half a million ounces were derived from silver-cobalt mines. Output was significantly lower than in 1974, mainly because of reduced output by the Silverfields Division of Teck Corporation Limited because of a labour strike which began July 12, 1975 and was still in effect at year-end.

About mid-1974 mining and milling operations at a rate of 120 tons of ore a day began at the property of Canadaka Mines Limited, a wholly-owned subsidiary of St. Joseph Explorations Limited. In addition to newly mined ore, the concentrator processed old mill tailings and material from old mine dumps. In May 1975 the concentrator was destroyed by fire and is being replaced by a new concentrator which is expected to begin operating in mid-1976.

Manitoba-Saskatchewan. In 1975 much of the silver produced in Manitoba and Saskatchewan came from nine base-metal mines operated by Hudson Bay Mining and Smelting Co., Limited near Flin Flon and Snow Lake, Manitoba. Substantial quantities were also derived from the Fox and Ruttan copper-zinc mines operated by Sherritt Gordon Mines Limited at Lynn Lake and Ruttan, Manitoba, respectively.

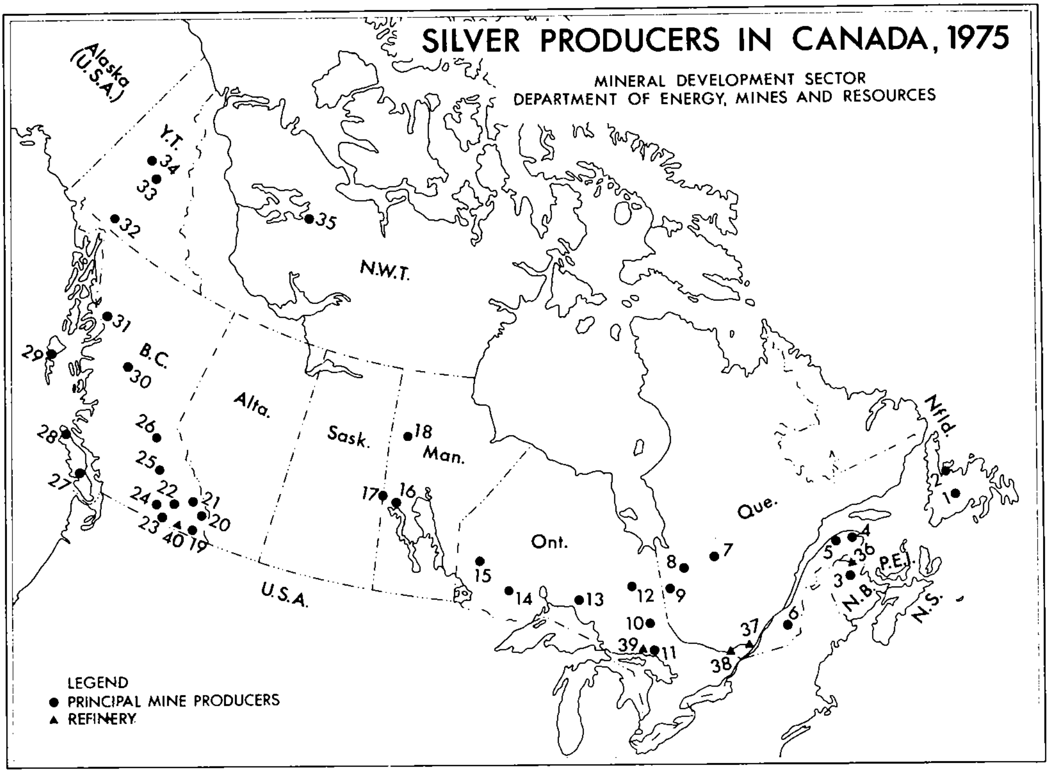
Development work at Hudson Bay's Centennial mine, nine miles southeast of Flin Flon, Manitoba, has indicated an orebody of 1,400,000 tons to a depth of 1,200 feet. The orebody grades 2.06 per cent copper, 2.6 per cent zinc, 0.04 ounce of gold and 0.70 ounce of silver a ton, and is still open at depth. Shaft sinking began January 8, 1975 and by year-end a depth of 1,411 feet had been reached. Development work continued at Hudson Bay's Westarm mine on the west arm of Schist Lake about nine miles south of Flin Flon, Manitoba. Shaft sinking began June 1, 1975 and totalled 1,457 feet at year-end.

At Sherritt Gordon's Fox mine it was planned to deepen the mine in 1976 by extending the access decline from the 2,200-foot level to the 2,400-foot level. It was also planned to put the Fox mine on a five-day week early in 1976 and thereby reduce its ore production by about 25 per cent. At Sherritt Gordon's Ruttan mine the planned annual rate of ore production was decreased from 3,500,000 to 2,800,000 tons, commencing in December 1975. The Ruttan concentrator was also converted to a five-day-week schedule.

British Columbia. Base-metal ores continued to be the main source of British Columbia's mine output of silver. Cominco Ltd., the largest silver producer in the province, derived its output from the lead-zinc-silver ores of its Sullivan mine and from purchased ores and concentrates. Byproduct silver output from the Sullivan mine was considerably higher in 1975 than in 1974 because of a four-month suspension of operations caused by a labour strike in 1974. Due to depressed copper prices, some of British Columbia's copper producers curtailed operations in 1975 and thereby reduced their byproduct silver output.

Operations at the zinc-lead-silver property of Reeves MacDonald Mines Limited at Remac, British Columbia, were suspended in March 1975 because the operations had become uneconomic. The company disposed of certain mine equipment and supplies and placed the mine and mill, which had been in operation since 1949, in a standby condition.

At the end of July 1975 Dankoe Mines Ltd. ceased milling operations at its silver-base metals property about 12 miles south of Keremeos in south-central British Columbia. Under the terms of an agreement made late in 1974 with Dusty Mac Mines Ltd., Dankoe's 450-ton-a-day concentrator began in August 1975 to custom-treat 10,000 tons of ore a month from the Dusty Mac gold-silver property in the nearby Okanagan Falls area. Dusty Mac's measured ore reserves have been reported to be some 133,000 tons averaging 0.20 ounce of gold and 3.60 ounces of silver a ton.



Principal Mine Producers

(numbers refer to numbers on the map)

1. ASARCO Incorporated. (Buchans Unit)
2. Consolidated Rambler Mines Limited
3. Brunswick Mining and Smelting Corporation Limited (Nos. 12 and 6 mines)
   Heath Steele Mines Limited
   Nigadoo River Mines Limited
4. Gaspé Copper Mines, Limited
5. Madeleine Mines Ltd.
6. Clinton Copper Mines Ltd.
   Sullivan Mining Group Ltd., Cupra Division and D'Estrie Mining Company Ltd.
7. Campbell Chibougamau Mines Ltd.
   Falconbridge Copper Limited, Opemiska Division
   Patino Mines (Quebec) Limited
8. Mattagami Lake Mines Limited
   Orchan Mines Limited
9. Falconbridge Copper Limited, Lake Dufault Division
   Manitou-Barvue Mines Limited
   Noranda Mines Limited, Horne Division
   Normetal Mines Limited
10. Agnico-Eagle Mines Limited
    Canadaka Mines Limited
    Teck Corporation Limited, Silverfields Division
11. Falconbridge Nickel Mines Limited
    The International Nickel Company of Canada, Limited
12. Texasgulf Canada Ltd., Kidd Creek mine
13. Noranda Mines Limited, Geco Division
    Willroy Mines Limited
14. Falconbridge Copper Limited, Sturgeon Lake Joint Venture
    Mattabi Mines Limited
15. Selco Mining Corporation Limited, South Bay Division
16. Hudson Bay Mining and Smelting Co., Limited (Anderson Lake, Chisel Lake, Dickstone, Osborne Lake, and Stall Lake mines)
17. Hudson Bay Mining and Smelting Co., Limited (Flin Flon, Ghost Lake, Schist Lake and White Lake mines)
18. Sherritt Gordon Mines Limited (Fox and Ruttan mines)
19. Reeves MacDonald Mines Limited
20. Cominco Ltd. (Sullivan mine)

21. Consolidated Columbia River Mines Ltd., Ruth-Vermont mine
    Kam-Kotia Mines Limited, Silmonac mine
22. Brenda Mines Ltd.
    Similkameen Mining Company Limited
23. Granby Mining Corporation, Phoenix Copper Division
24. Dankoe Mines Ltd.
    Dusty Mac Mines Ltd.
    Teck Corporation Limited (Beaverdell mine)
25. Bethlehem Copper Corporation
    Lornex Mining Corporation Ltd.
26. Gibraltar Mines Ltd.
27. Western Mines Limited
28. Utah Mines Ltd.
29. Wesfrob Mines Limited
30. Granisle Copper Limited
31. Granduc Operating Company
32. Whitehorse Copper Mines Ltd.
33. Cyprus Anvil Mining Corporation
34. United Keno Hill Mines Limited
35. Echo Bay Mines Ltd.
    Terra Mining and Exploration Limited

Refineries

(numbers refer to numbers on the map)

36. Brunswick Mining and Smelting Corporation Limited, Smelting Division
37. Canadian Copper Refiners Limited
38. Royal Canadian Mint
39. The International Nickel Company of Canada, Limited
40. Cominco Ltd.

Northair Mines Ltd. continued underground exploration and development work, as well as mill construction, at its Brandywine Falls silver-gold-base-metals property about 70 miles north of Vancouver. It was expected that the property would be brought into production early in 1976 at a rate of 300 tons of ore a day. Cost of the project has been estimated at $4 million. The property is a multivein deposit with the more important ore zones being the Warman, Manifold and Discovery zones. Total ore reserves have been estimated at 459,200 tons averaging 3.5 ounces of silver and 0.46 ounce of gold a ton. The ore also contains additional values in copper, lead and zinc.

Development work continued in 1975 on Equity Mining Capital Limited's Sam Goosly silver-gold-copper property 40 miles south of Smithers, B.C. The final feasibility study was expected to be completed in the second quarter of 1976. The study is being made to determine the merits of bringing the property into production at a rate of 3,200 tons of ore a day, with later expansion to 5,000 tons daily. Reserves of ore mineable by open-pit methods have been estimated at 43.5 million tons grading 2.78 ounces of silver and 0.026 ounce of gold a ton, and 0.33 per cent copper. Equity Mining and Congdon and Carey Company of Denver, Colorado, share equally a 70 per cent working interest in the property, with Kennco Explorations (Western) Limited, a subsidiary of Kennecott Copper Corporation, holding a 30 per cent carried interest. The undertaking is managed by Equity Mining.

Northwest Territories. Silver production in the Northwest Territories was significantly lower in 1975 than in 1974 because of reduced output by Echo Bay Mines Ltd. at its silver-copper property near Port Radium on the east shore of Great Bear Lake.

On Baffin Island construction of mine and concentrator facilities for the first commercial mine in North America north of the Arctic Circle continued on schedule. It is the lead-zinc-silver property of Mineral Resources International Limited (MRI) at Strathcona Sound, 500 miles north of the Arctic Circle, in which Texasgulf Inc. has a 35 per cent carried interest. The property is to be operated by Nanisivik Mines Ltd. Nanisivik is owned 59.5 per cent by MRI, 18.0 per cent by the Canadian government and 11.25 per cent each by Metallgesellschaft A.G. of West Germany and Billiton N.V. of the Netherlands. It is expected that the property will be brought into production late in 1976 at a rate of 1,500 tons of ore a day at a cost now estimated at about $60 million. Ore reserves have been estimated at some 7 million tons averaging 14.1 per cent zinc, 1.4 per cent lead and 1.8 ounces of silver a ton.

At Izok Lake in the Northwest Territories, 224 miles north of Yellowknife, Texasgulf Inc. discovered an important base-metal sulphide deposit in 1975. Three sulphide zones have been indicated. The central zone, which remains open to the east, has been diamond drilled over a strike length of 1,400 feet and contains over 7 million tons of indicated ore with an average grade of 3.15 per cent copper, 14.8 per cent zinc, 1.2 per cent lead, and 1.85 ounces of silver a ton. The top of the orebody is at or near the surface making it suitable for an open-pit mining operation. It was planned to resume diamond drilling of the deposit in April 1976.

Yukon Territory. Silver production in the Yukon Territory was somewhat higher in 1975 than in 1974. The two principal producers continued to be Cyprus Anvil Mining Corporation and United Keno Hill Mines Limited. At United Keno, the potential for finding new ore reserves diminished in 1975. Ore reserves declined at the company's Husky Mine, which is the major production unit, and the Townsite Mine was closed because of low-grade production. Although ore reserves at the Faro orebodies of Cyrpus Anvil are estimated to be sufficient to last about 12 years at the current rate of production, the company plans to continue substantial exploration work to find additional ore.

Kerr Addison Mines Limited continued exploration and development work at the Grum zinc-lead-silver deposit in the Vangorda Creek area, about eight miles southeast of the Cyprus Anvil operation near Faro, Y.T. The Grum Joint Venture is owned 60 per cent by Kerr Addison and 40 per cent by Aex Minerals Corporation. Expenditures on the Grum deposit in 1975 amounted to $5.2 million. Development work includes driving a 14-foot by 14-foot ramp decline for a length of 4,100 feet from surface. Late in 1975 the deposit was reported to contain some 32 million tons averaging 10 per cent combined zinc and lead, and 2.0 ounces of silver a ton, with a zinc-lead ratio of about two to one.

Uses

Although the number of industrial applications for silver has increased, significant quantities of the metal are still used in the manufacture of coinage, especially commemorative coins. This is because it strongly resists corrosion, has good alloying properties, an attractive appearance and intrinsic value. The quantity of silver required for coinage increased somewhat in 1975 partly because of a significant quantity of silver used in the United States for minting 40 per cent-silver coins commemorating the Bicentennial of the American Revolution in 1976. According to Handy & Harman, noncommunust world consumption of silver for coinage dropped from a high of 381.1 million ounces in 1965 to 23.7 million ounces in 1973 and then increased to 35.0 million ounces in 1975. Silver is used extensively in jewelry, sterling and plated silverware, and as a decorative material, because of the same properties that made it popular in the past as a coinage metal, as well as for its high malleability, ductility and ability to take a fine finish. Partly because of the higher gold price, the use of silver in jewelry increased significantly in 1975. Phillips Petroleum Company recently developed a very promising anti-tarnish compound called Meos which permits treated silver to remain untarnished 20 to 60 times longer than untreated silver. The photographic industry, in which the use of silver is based on the light sensitivity and ease of reduction of certain silver compounds, is still the metal's greatest single user. The light-sensitive silver halide emultion on photographic film is the compound that preserves the image after the camera shutter has snapped. In 1975 photographic materials accounted for about 29.2* per cent of total industrial consumption of silver in the United States. Higher silver prices in recent years have also helped to bring about technological developments which have led to less usage of silver in photography, particularly in the area of x-ray film. Substitution for traditional x-ray film is found in scanners, which use a computer to synthesize numbers from an electronic detector receiving x-ray beams, and then display the picture on a TV-like screen. One such method of silverless x-ray technique makes x-ray pictures on low-cost thin plastic sheets instead of expensive photographic film. While such new photographic processes which require no silver have been developed in black and white photography, the new techniques are not yet adaptable to color films. Silver-sensitized film for printing purposes is being increasingly replaced by electronic devices and photopolymer films. Copying through xerography, and the use of contact lithographic films with no silver, are also contributing to the reduction of the printing industry's use of silver, even though these processes are only suitable for low-definition copy work. In spite of the progress that has been made in the development of silverless photographic processes, a major breakthrough does not yet appear to be on the horizon, especially in the field of colour films. Even if a satisfactory substitute should be found, it could take several years to effect the transition.

* Based on figures contained in Table 6.

Table 6. United States consumption of silver by end use[1], 1974-75

	1974[3]	1975[3]
	(troy ounces)	
Electroplated ware	13,178,917	8,717,106
Sterling ware	22,146,679	23,716,885
Jewelry	5,235,193	12,733,612
Photographic materials	49,578,607	46,074,440
Dental and medical supplies	2,401,180	1,502,583
Mirrors	3,946,665	3,150,092
Brazing alloys and solders	14,514,008	13,582,447
Electrical and electronic products:		
Batteries	4,194,815	4,253,454
Contacts and conductors	31,318,049	27,210,776
Bearings	416,144	457,620
Catalysts	7,293,245	8,784,846
Coins, medallions, and commemorative objects	22,272,396	7,185,514
Miscellaneous[2]	518,796	280,809
Total net industrial consumption	177,014,694	157,650,184
Coinage	1,016,600	2,739,900
Total consumption	178,031,294	160,390,084

Sources: United States Department of the Interior, Bureau of Mines, Mineral Industry Surveys, Gold and Silver in December 1975, for 1974 statistics; United States Department of the Interior, Bureau of Mines, Mineral Industry Surveys, Gold and Silver in March 1976, for 1975 statistics.
[1]End use as reported by converters of refined silver. [2]Includes silver-bearing copper, silver-bearing lead anodes, ceramic paints, etc. [3]Final figures: includes companies reporting annually.

Substantial quantities of silver are used in the electrical and electronics industries because of the good demand for silver contacts, conductors and other silver-bearing components. These applications include extensive quantities of silver used in the component parts of complex electronics systems to assure maximum conductivity and reliability in guidance systems for spacecraft. In 1975, electrical and electronic products accounted for about 20* per cent of total industrial consumption of silver in the United States. Silver is an important constituent of many brazing and soldering alloys because of the low melting point of silver-copper and silver-copper-zinc alloys, their resistance to corrosion, high tensile strength and ability to join together almost all nonferrous metals and alloys as well as iron and silver. These solders and brazing alloys are widely used in the manufacture of air conditioning and refrigeration equipment, electrical appliances and automotive parts.

Silver-zinc and silver-cadmium batteries, in spite of their limited life when in use, are increasingly used in portable equipment where good output, long shelf life and rechargeability are required. However, because of their high cost, such silver-containing batteries are restricted to applications where the requirements are rigorous, especially where weight and dependability are of prime importance such as in jet aircraft, missiles, satellites and space capsules. High-energy silver-zinc batteries played a vital part in the historic Apollo flights to the moon, servicing both the command and lunar excursion modules. Silver-zinc batteries powered TV transmissions from Apollo 17's Lunar Rover. Similar batteries also provide high-intensity light for lanterns and flashlights for plant protection and security officers. A single silver-zinc battery in a nuclear submarine may use as much as 168,000 ounces of silver.

An increase in the use of silver in the battery field could develop as a result of extensive research being done in the use of silver-zinc batteries to power motorcycles and small cars. Corbin-Gentry, Incorporated of Sommerville, Connecticut and Dallas, Texas hopes by 1977 to have a production model on the market of a motorcycle powered by a silver-zinc battery made by Yardney Electric Corp. of Pawcatuck, Connecticut. This motorcycle is expected to have a range of 150 miles and speeds of 50 miles an hour or better. Yardney is the company that attracted considerable attention a few years ago by converting several small cars to electric motors using silver-zinc batteries and produced some impressive performance figures. It has also been reported that electric motorcycles powered by silver-zinc batteries have much better hill climbing abilities than similar vehicles fuelled by lead-acid batteries. The silver-zinc battery would, however, have to be leased instead of purchased by the users of such motorcycles and small cars because its purchase price would be prohibitive. Since the sizeable silver content of such batteries is fully recoverable at the end of their useful lives, marketing on a rental basis is thought to be quite feasible.

Silver is used as a catalyst to control the oxidation of methanol to formaldehyde, and ethylene to ethylene oxide, all of which is essential to the production of plastics, antifreeze and polyester products. Silver catalysts are also used in the manufacture of carpets and permanent-press synthetic fabrics. Another growing industrial use is the almost invisible silver threads embedded in the glass of rear windows of automobiles. The threads are connected to the vehicle's battery and serve as heaters to de-ice and de-fog the windows. A low-cost, highly effective silver nitrate cream has been developed for the treatment of severe burns. Silver powder, 99.999 per cent pure, in the form of round beads has applications in powder metallurgy, electronic circuits, and in silver brazing. Meteorological applications involving the use of silver iodide for cloud seeding to produce rain could become a significant outlet for silver, as many countries are making efforts to regulate the weather. Other new outlets for the metal are as fungicides and bactericides because of the increasing attention being paid to the ecology and environment. Research is being done on the use of silver in compounds for the improved treatment of swimming-pool water. Tests indicate that the addition of small amounts of silver or silver compounds can significantly reduce the quantities of other chemicals used in swimming pools for purification purposes. Recycling water with minute quantities of silver chloride also helps to eliminate unpleasant odours and tastes in the water and acts as a bactericide. Silver chloride, which has recently become available in the form of a fine-sized, free-flowing powder, is used in the treatment of water to remove slime, algae and bacteria. It is also used in industrial and laboratory applications.

A new system called "laser photo" was recently developed. This system will enable an office to transmit, within minutes, a detailed positive print photograph to a branch office a continent away, without requiring wet processing or other intermediate steps. This new application for silver uses a laser as a light source and dry silver paper as the reproductive medium, which is processed simply by the application of heat.

Another potential use for silver is in the conversion of solar energy. Recent experimental work indicates that a central-receiver solar energy system using a one-square-mile array of silver-backed mirrors could generate enough thermal energy to supply a population centre of 100,000 people. Such an apparatus could involve the use of more than 32,000 ounces of silver. Some observers believe that the first single plant using such a central receiver system should be in operation in the United States by 1985. They anticipate that by the year 2000 these systems could furnish up to 20 per cent of anticipated United States thermal energy needs — and require a silver supply equivalent to a few years of present world output. In such solar energy systems, silver-backed mirrors catch and reflect the sun's light rays to produce heat; this heat can then be used to generate electricity. Heat produced from these developing solar systems is also thought to be competitive with present fuel oil in costs.

* Based on figures contained in Table 6.

Table 7. Annual average silver prices: Canada, United States and United Kingdom, 1966-75

	Canada	United States Handy & Harman, New York	United Kingdom London Spot	London Spot
	($ Can.)	($ U.S.)	(pence)	($ U.S. equiv.)[3]
		(per troy ounce)		
1966	1.398	1.293	111.815	1.301
1967	1.725	1.550	141.977	1.626
1968	2.311	2.145	219.529	2.189
1969	1.931	1.791	180.774	1.800
1970	1.851	1.771	177.068	1.768
1971	1.571	1.546	63.086[2]	1.542
1972	1.671	1.685	67.403[2]	1.686
1973	2.567	2.558[1]	103.783[2]	2.544
1974	4.595	4.708	199.819[2]	4.675
1975	4.503	4.419	200.118[2]	4.446

Sources: Canadian prices are those quoted by *The Northern Miner* (arithmetical average of daily quotations). United States and United Kingdom prices are those quoted by *Metals Week*.
[1]The 60-day general price freeze in effect in the United States from June 13 through August 12, 1973 forced intermittent suspension of Handy and Harman's daily quotation during July and August for a total of 22 days. [2]1971-75 prices are expressed in new British pence, following British conversion to decimal currency, February 11, 1971, at the rate of 100 pence per pound sterling. Previous rate was 240 pence per pound. [3]Prices have been converted at the yearly average exchange rates quoted by Metals Week.

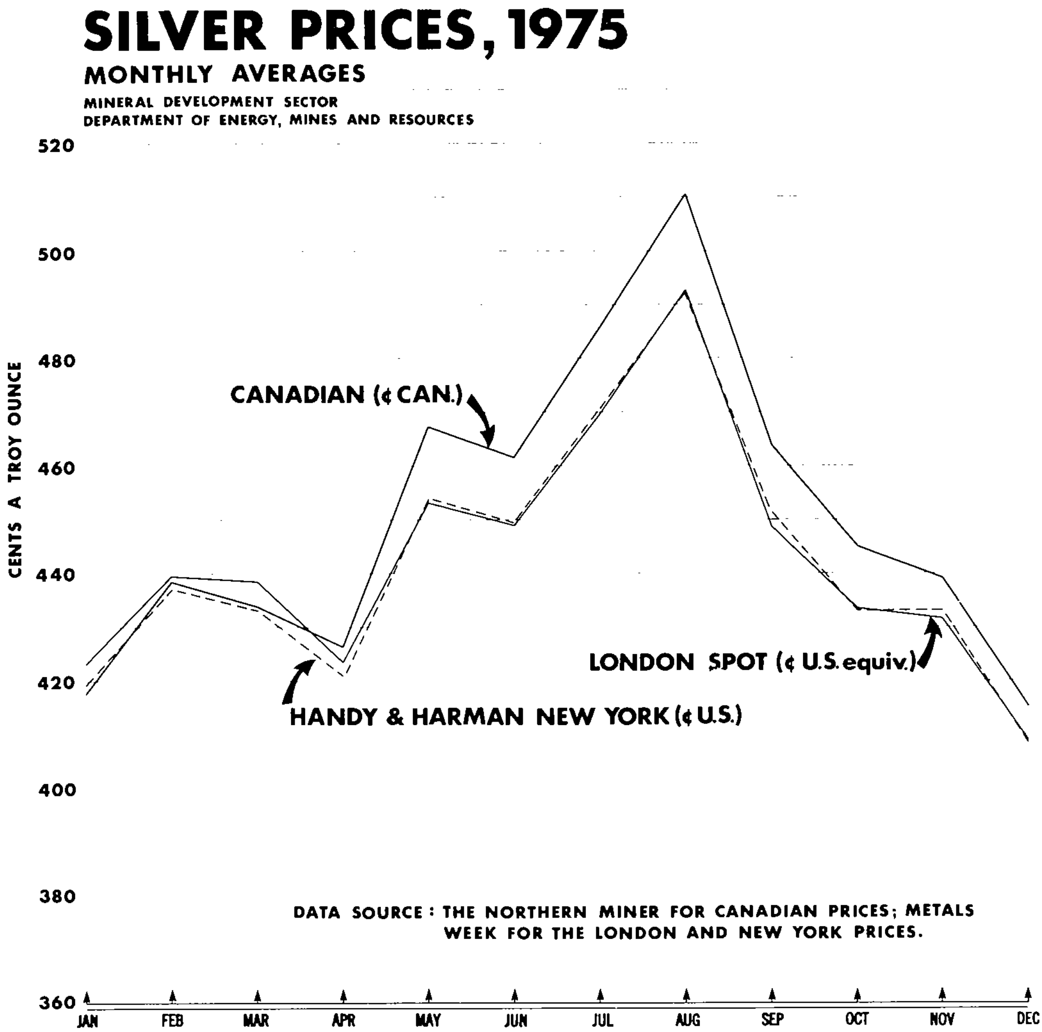
The optical properties of silver are distinctive because of its exceptionally-high reflectivity and very low emissivity. Polished silver surfaces have a reflection coefficient of about 80 to 95 per cent depending on the wave length of the sun's light rays. Because of these optical properties, silver is currently considered the best material, perhaps through several system concepts, for heating homes and buildings. Substitutes for silver include super-purity aluminum, and possibly copper; in fact, aluminum has been used on an experimental basis as a collector of sun rays for heating purposes, but the coefficient of reflectivity of both aluminum and copper is lower than that of silver, based on wave lengths of the sun's light rays in the visible range. For the same reason, it is not thought that the platinum group metals will be used for this application. Studies indicate that the solar energy derived from a silver-using process requires about one-third less power to produce than a similar process using aluminum. There are now four major United States companies competing in the field of solar energy research and development, namely McDonnell Douglas Aeronautics, Martin Marietta Corp., Rockwell International Corp. and Boeing Aircraft.

Silver is being increasingly used with tin in low-temperature soldering applications. Comparisons of the mechanical properties of 95 per cent tin-5 per cent silver solders with 80 per cent lead-20 per cent tin solders, show that both the ultimate tensile strength and the shear strength of the silver-containing solders are approximately twice that of the lead-tin products. The silver solders are also about 30 per cent harder, and elongate less than one-fourth as much as the lead-tin solders when the end products have to withstand stress, impact or heat. Also, tin-silver solders are non-toxic, which is an essentail consideration for joints that come in contact with food or drink. Applications today vary from plumbing, heating, refrigeration and air conditioning, to food service and processing utensils, holloware and the electronics industry. Because of the non-toxicity of tin-silver solders, this application could result in significant increases in silver usage in countries where the laws on toxicity might be made more stringent.

While silver has been used for years in dentistry, Russian and Japanese experts have reportedly developed a non-toxic silver amalgam with gallium to fill cavities in teeth. Also, researchers have recently unveiled a cyanide-free silver electroplating solution. The new product is said to be comparable to the best available silver baths containing cyanide. In addition to being able to comply with anti-pollution measures, the non-cyanide silver solution is believed to have good electroplating qualities.

Prices

In 1975 the New York Handy & Harman silver price displayed another year of volatility. On January 2, the price was $4.270 an ounce. A low of $3.945 obtained on January 22 and a high of $5.225 was reached on August 7; at year-end the price was $4.165. Average for the year was $4.419. The London spot silver price ranged between a low of 167.1 pence an ounce, equivalent to $3.988(US), on January 23, and a high of 248.1 pence ($5.211 (US)), on August 8. At year-end the price was 206.5 pence ($4.179 (US)). Average for the year was 200.1 pence ($4.446 (US)). In 1975 the Canadian silver price closely followed its United States counterpart, with the essential difference being the currency exchange rate. It fluctuated between a low of $3.925 Can. an ounce on January 22 and a high of $5.413 on August 7. At year-end the price was $4.239. Average for the year was $4.503.


SILVER PRICES, 1975
MONTHLY AVERAGES
MINERAL DEVELOPMENT SECTOR
DEPARTMENT OF ENERGY, MINES AND RESOURCES
CENTS A TROY OUNCE
520
500
480
460
440
420
400
380
360
CANADIAN (¢ CAN.)
LONDON SPOT (¢ U.S. equiv.)
HANDY & HARMAN NEW YORK (¢ U.S.)
DATA SOURCE : THE NORTHERN MINER FOR CANADIAN PRICES; METALS WEEK FOR THE LONDON AND NEW YORK PRICES.
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC

Tariffs

Canada

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
32900-1	Ores of metals, nop	free	free	free	free
35800-1	Anodes of silver	free	free	10%	free
35900-1	Silver in ingots, blocks, bars, drops, sheets or plates, unmanufactured; silver sweepings	free	free	free	free
35905-1	Scrap silver and metal alloy scrap containing silver (expires October 31, 1978)	free	free	25%	free
36100-1	Silver leaf	12½%	20%	30%	12½%
36200-1	Articles consisting wholly or in part of sterling or other silverware, nop; manufactures of silver, nop	17½%	22½%	45%	15%

United States[1]

Item No.		
420.60	Silver compounds	5%
601.39	Precious metal ores, silver content	free
605.20	Silver bullion, silver dore and silver precipitates	free
605.46	Platinum-plated silver, unwrought or semimanufactured	16%
605.47	Gold-plated silver, unwrought or semimanufactured	25%
605.48	Other unwrought or semimanufactured silver	10.5%
605.65	Rolled silver, unworked or semimanufactured	10.5%
605.70	Precious metal sweepings and other precious metal waste and scrap, silver content	free
644.56	Silver leaf	2.5¢ per 100 leaves

Sources: For Canada, the Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa. For United States, Tariff Schedules of the United States Annotated (1976), TC Publication 749.
[1]Tariff rates applicable to products of Canada imported directly or indirectly into the customs territory of the United States.
nop: Not otherwise provided for.

Sodium Sulphate

A.F. KILLIN

Sodium sulphate (Na_2SO_4), commonly known as "salt cake", is an industrial chemical used principally in the manufacture of pulp and paper by the "kraft" process, and in the manufacture of glass and detergents. It can be produced from natural deposits and brines in alkaline lakes in areas with dry climates and little or no drainage, from subsurface deposits and brines, or as a byproduct of chemical processes. Canada's sodium sulphate industry is based on natural brines and deposits in many alkaline lakes in the southern prairies of Saskatchewan and Alberta. Seven plants operated in Canada in 1975. Small quantities of byproduct sodium sulphate are recovered at a viscose-rayon plant and at a pulp and paper mill in Ontario, and at a strontium sulphate-carbonate plant in Nova Scotia.

In the United States, naturally-occurring sodium sulphate is produced in California, Utah, Texas and Wyoming, and byproduct salt cake is produced in the eastern states.

Production and developments in Canada

Shipments of sodium sulphate from Canadian producers in 1975 decreased to 546,000 tons, 22 per cent lower than in 1974. The value of the shipments in 1975 at $23,762,000 increased by 67 per cent from 1974, owing to higher shipments of detergent-grade material and to higher prices in 1975. Decreased shipments can be attributed to a drop in consumption in the pulp and paper industry because of prolonged strikes, and to production difficulties at some of the producing plants. The Saskatchewan Department of Mineral Resources reports production of sodium sulphate in 1975 at 465,628 tons.

Deposits. Apart from the lakes in Saskatchewan and Alberta, sodium sulphate has also been found associated with magnesium sulphate in British Columbia and with calcium sulphate in New Brunswick. The New Brunswick deposits are deeply buried and occur as glauberite, the anhydrous double sulphate of sodium and calcium.

The sodium sulphate deposits in Saskatchewan and the bordering areas of Alberta have formed in shallow, undrained lakes and ponds where run-off waters carry in dissolved sulphate from the surrounding soils. Through the years, high rates of summer evaporation have concentrated the brine, and cooler fall temperatures have caused sodium sulphate to crystallize out as mirabilite ($Na_2SO_4 \cdot 10H_2O$). The cycle has been repeated year after year and thick deposits of hydrous sodium sulphate, commonly known as Glauber's salt, have accumulated. Occasionally, some of the sodium sulphate formed is of the anhydrous variety known as thenardite (Na_2SO_4).

Some lakes have not accumulated thick beds because the crystals of sodium sulphate that are deposited during the fall and winter are re-dissolved each spring, to reform a brine rich in sodium sulphate. These same lakes commonly contain a high concentration of magnesium sulphate, a mineral that may prove valuable in the future.

Reserves in Saskatchewan have been estimated at 100 million tons of anhydrous sodium sulphate, of which about one-half is considered economically recoverable with current technology. Ten deposits in Saskatchewan each contain reserves ranging from 2 million to 9 million tons. One deposit in Alberta contains 3 million tons of Na_2SO_4.

Recovery and processing. For most Saskatchewan producers, weather is as important for the recovery of sodium sulphate as it is for its deposition. A supply of fresh water is also essential.

Sodium sulphate recovery generally begins by pumping concentrated lake brines into reservoirs during the summer. Pumping takes place when the brine is at the highest concentration. To supplement the brining system, one producer uses a floating dredge to excavate crystals from the lake bed and pumps a slurry directly to the processing plant.

The recovery cycle in the reservoir is completed when cool fall weather causes precipitation of hydrous sodium sulphate; excess fluid with impurities is drained or pumped back to the lake. The crystal bed, normally 2 to 4 feet deep, is then excavated by scrapers, shovels or draglines and moved to a stockpile. Stockpiling is done in the winter, and provides sufficient feed to operate a processing plant throughout the year.

Table 1. Canada, sodium sulphate production and trade, 1974-75

	1974		1975^p	
	(short tons)	($)	(short tons)	($)
Production				
Shipments	703,472	14,192,225	546,000	23,762,000
Imports				
Total salt cake and Glauber's salt				
Belgium and Luxembourg	3,362	83,000	8,476	382,000
United States	14,447	372,000	7,927	318,000
United Kingdom	7,014	157,000	8,547	276,000
Netherlands	—	—	4	4,000
Total	24,823	612,000	24,954	980,000
Exports				
Crude sodium sulphate				
United States	254,939	6,948,000	187,873	7,326,000
New Zealand	2,358	138,000	2,452	240,000
Thailand	500	25,000	1,800	148,000
Trinidad-Tobago	22	6,000	864	86,000
Malaysia	111	37,000	853	63,000
Australia	115	4,000	1,260	58,000
Other countries	2,889	178,000	1,229	108,000
Total	260,934	7,336,000	196,331	8,029,000

Source: Statistics Canada.
^{p} Preliminary; — Nil.

Processing consists essentially of the dehydration of the natural crystal (Glauber's salt contains 55.9 per cent H_2O by weight) and drying. Processing equipment includes submerged combustion units, evaporators, classifiers, centrifuges, rotary kiln dryers, screens and crushers. The end product, a powdery white substance, commonly known as salt cake, contains a minimum of 97 per cent Na_2SO_4 and can reach as much as 99.77 per cent. Uniform grain size and free flow are important in material handling and use.

The Alberta-based producer uses a solution recovery system rather than seasonal harvesting. The raw Glauber's salt is recovered from the lake bed by solution methods which have proven very successful during both summer and winter. The brine is then subjected to an evaporation and crystallization process to recover the sodium sulphate.

Francana Minerals Ltd. increased capacity at its Grant, Saskatchewan plant to 300 tons a day. The new Ellicott dredge did not operate at capacity in 1975 because of unfavourable weather conditions. The company's Hardene, Saskatchewan plant, that had been reactivated in 1974, was shut down in March, 1975 by a fire that destroyed the electrical motor control centre and the factory building. Production from the rebuilt plant was resumed in mid-July with increased production capability and a better environment for employees.

By- and co-product recovery. Courtaulds (Canada) Limited produced about 15,000 tons of byproduct sodium sulphate in 1975 from its Cornwall, Ontario viscose-rayon plant.

Kaiser Strontium Products Limited, a subsidiary of Kaiser Aluminum & Chemical Canada Investment Limited, recovered co-product salt cake at Point Edward, Nova Scotia. At the plant, strontium sulphate concentrates are reacted with natural sodium carbonate to produce strontium carbonate and sodium sulphate. The designed capacity is 90 tons of strontium carbonate and 100 tons of sodium sulphate a day.

In July 1973, Ontario Paper Company Limited brought on stream a byproduct salt cake unit at its paper mill at Thorold, Ontario with a rated capacity of about 80 tons a day.

Consumption and trade

There are three main users of sodium sulphate; the kraft pulp and paper industry, the detergent industry and the glass industry. Other uses include the dyeing industry, mineral-feed supplements, chemical products and base metal smelting. Consumption in the pulp and paper industry was reduced in 1975 by prolonged strikes at the pulp mills. In normal years, the pulp and paper industry consumes approximately 80 per cent of the sodium sulphate used in Canada.

Table 2. Canada, sodium sulphate production, trade and consumption, 1966-75ᵖ

	Production[1]	Imports[2]	Exports	Consumption
	(short tons)			
1966	405,314	31,261	101,417	336,346
1967	428,316	27,621	123,833	347,140
1968	459,669	25,018	108,984	391,953
1969	518,299	29,609	120,414	437,055
1970	490,547	29,155	119,888	406,812
1971	481,919	21,299	122,523	401,908
1972	507,275	26,960	131,162	429,080
1973	543,354	29,805	157,672	300,080
1974	703,472	24,823	260,934	336,608
1975ᵖ	546,000	24,954	196,331	. .

Source: Statistics Canada.
[1] Producers' shipments of crude sodium sulphate. [2]Includes Glauber's salt and crude salt cake.
ᵖ Preliminary; . . Not available.

Table 4. Canada, available data on sodium sulphate consumption, 1973-75

	1973	1974	1975
	(short tons)		
Pulp and paper	245,009	271,401	
Glass and glass wool	7,563	12,890	
Soaps	20,372	28,494	
Other products[1]	27,136	23,823	
Total	300,080	336,608	. .

Source: Statistics Canada, breakdown by Mineral Development Sector.
[1]Colours, pigments, foundries, feed supplements and other minor uses.
. . Not available.

Table 3. Canada, natural sodium sulphate plants, 1975

	Plant Location	Source Lake	Annual Capacity
			(st)
Alberta			
Alberta Sulphate Limited	Metiskow	Horseshoe	100,000
Saskatchewan			
Francana Minerals Ltd.	Grant	Snakehole	100,000
Francana Minerals Ltd.	Hardene[1]	Alsask	50,000
Midwest Chemicals Limited	Palo	Whitehorse	120,000
Ormiston Mining and Smelting Co. Ltd.	Ormiston	Horseshoe	100,000
Saskatchewan Minerals	Chaplin	Chaplin	150,000
Saskatchewan Minerals	Bishopric	Frederick	40,000
Saskatchewan Minerals	Fox Valley	Ingebrigt	150,000
Sybouts Sodium Sulphate Co., Ltd.	Gladmar	East Coteau	50,000
Total			860,000

Source: Company reports.
[1]Reactivated in 1974.

Canada is the third largest exporter of sodium sulphate among the non-Comecon nations. Over 90 per cent of Canadian exports go to the United States. Total exports in 1975 at 196,331 tons were 25 per cent lower than in 1974. Imports, at 24,954 tons were only 131 tons more than in 1974.

Outlook

A resumption of demand by the pulp and paper industry, coupled with an expected improvement in the level of industrial activity in 1976, should provide a stable demand for sodium sulphate. There will likely be some pressure on available supplies and prices could increase to reflect increased costs of labour and materials.

Prices

Prices of sodium sulphate fob works rose from $30 a short ton, bulk carload lots for "salt cake" and $38 for detergent grade in January to $40 a short ton for "salt cake" and $87.40 for detergent grade in December.

Canadian prices of sodium sulphate, as quoted by Canadian Chemical Processing Buyers Guide, December 1975.

	($ Canadian per short ton)
Sodium sulphate (salt cake) Bulk, carlots, fob works	40.00
Detergent-grade bulk, fob works	87.40

United States prices according to Chemical Marketing Reporter, December 29, 1975.

	($ U.S. per short ton)
Salt cake, 100% NA_2SO_4 basis, fob plant East	60.00
Same basis, West	35.00
Sodium sulphate, detergent rayon-grade, bags, carlots, works, East	60.00-65.00

Tariffs

Canada

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
21000-1	Natural sodium sulphate	10%	15%	25%	10%

United States

Item No.		
421-42	Crude sodium sulphate (salt cake)	Free
421-44	Anhydrous	40¢ per long ton
421-46	Crystallized (Glauber's salt)	80¢ per long ton

Sources: The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa. Tariff Schedules of the United States Annotated, (1976), TC Publication 749.

Stone

D.H. STONEHOUSE

Naturally occurring rock material quarried or mined for industrial use with no change in its chemical state and with its physical character altered only by shaping or by sizing, is commercially termed "stone". Dimension stone is shaped for use as a building block, slab or panel. It may be rough cut, sawn or polished, and its application may depend on its strength, hardness, durability and ornamental qualities. Broken, irregular, screened and sized pieces constitute the crushed stone category. It is used mainly as an aggregate in concrete and asphalt, in highway and railway construction and as heavy riprap for facing wharves and breakwaters.

Stone production in Canada, either as dimension stone or crushed stone, is used directly or indirectly by the construction industry, except for small amounts used in the manufacture of monuments. Indirect usage includes that portion of the resource that is utilized by the chemical industry (mainly limestone) for the manufacture of lime, cement, iron and steel, all of which are associated with various phases of the construction industry. Activity in both building construction and heavy or engineering construction can be indicative of demands for quarried stone.

The large number of stone-producing operations in Canada precludes describing within this review individual plants or facilities. Many are part-time or seasonal operations, many are operated subsidiary to construction or manufacturing activities by establishments not classified to the stone industry, and some are operated directly by municipal or provincial government departments producing stone for their own direct use. Detailed information can be obtained through the individual provincial departments of mines or equivalent. Most provinces have accumulated data relative to occurrences of stone of all types and in many cases have published such studies. The federal government, through the Geological Survey of Canada, has also gathered and published a great number of geological papers pertaining to stone occurrences. Works by W.A. Parks[1] and by M.F. Goudge[2] have become classics in the fields of building stones and limestones, respectively.

Dimension stone. Granite, limestone, marble and sandstone are the principal rock types from which building and ornamental stone is fashioned. Construction uses account for over 85 per cent of the consumption of building and ornamental stone produced and sold in Canada; the remainder is used as monumental stone.

Today, in the building sector of the construction industry, granite, limestone and marble are used as facing stone in the form of cut and polished panels in conjunction with steel and concrete for institutional and commercial buildings. In residential buildings, the use of a limestone or sandstone ashlar, or coursing stone, is becoming increasingly popular. The emphasis has changed from stone used for structural qualities to stone used for its aesthetic qualities. The architect and contractor can design and build for lasting beauty using Canadian building stone.

Crushed stone. Many quarries that produce crushed stone are operated primarily to produce stone for other purpose, e.g. granite for building blocks and monuments, limestone for cement or lime manufacture, or for metallurgical use, marble for monuments and building panels, sandstone for riprap, and cut stone. Quarries removing solid rock by drilling, blasting and crushing are not likely to be operated for small, local needs as are gravel pits and are, therefore, usually operated by large companies associated with the construction industry. Depending on cost and availability, crushed stone competes with gravel and crushed gravel as an aggregate in concrete and asphalt and as railway ballast and road metal. In these applications, it is subject to the same physical and chemical testing procedures as the gravel and sand aggregates.

Other uses for crushed stone include the manufacture of roofing granules from granite and marble, the production of poultry grit from limestone, silica and granite, and the production of rock wool from limestone and sandstone. Pulverized stone is used as follows: granite, limestone and sandstone as asphalt filler; limestone for dusting coal mines; and limestone and marble for agricultural application.

Limestone is also produced for chemical and metallurgical uses in the iron and steel industry, the glass industry, the pulp and paper industry and in sugar manufacture.

Canadian industry

Atlantic provinces. *Limestone.* The many occurrences of limestones in the Atlantic provinces have been systematically catalogued during the past few years.[3,4,5] Deposits of commercial importance are being worked in three of the four provinces.

In Newfoundland, limestone is available from small, impure exposures in the eastern portion of the island; from small, high-calcium deposits in the central region; and from large, high-purity, high-calcium occurrences in the west. Other than periodic operation to secure aggregate for highway work, the main exploitation is by North Star Cement Limited at Corner Brook.[6] Lehigh Portland Cement Company, Allentown, Pennsylvania, in association with British Newfoundland Exploration Limited (Brinex), assessed the limestones in the Port au Port district with the objective of establishing a 1-million-ton-a-year portland cement facility in the region. A buoyant export market for portland cement or for clinker would be necessary in order to support a plant of such capability. Early in 1975 Lehigh terminated its agreement with Brinex, and

Table 1. Canada, total production (shipments) of stone, 1973-75

	1973		1974		1975^p	
	(short tons)	($)	(short tons)	($)	(short tons)	($)
By province						
Newfoundland	394,311	971,537	679,826	2,043,999	600,000	1,900,000
Prince Edward Island	—	—	—	—	—	—
Nova Scotia	812,928	1,732,872	1,665,800	4,585,868	1,300,000	4,300,000
New Brunswick	2,756,277	5,486,450	3,122,769	6,574,573	2,600,000	5,200,000
Quebec	48,155,998	58,459,217	55,130,376	88,239,227	53,100,000	84,200,000
Ontario	35,539,327	52,869,733	34,459,673	60,916,200	33,700,000	62,000,000
Manitoba	625,282	1,016,676	2,450,513	3,384,453	1,700,000	2,600,000
Alberta	160,644	810,935	180,054	892,096	200,000	1,000,000
British Columbia	3,829,421	7,345,183	4,641,915	10,570,662	3,900,000	9,500,000
Canada	92,274,188	128,692,603	102,330,926	177,207,078	97,100,000	170,700,000
By use						
Building stone						
Rough	55,963	1,495,757	86,785	2,018,794		
Dressed	—	—	—	—		
Monumental, ornamental stone						
Rough	29,954	1,422,394	31,106	1,330,541		
Dressed	—	—	—	—		
Flagstone	60,486[1]	524,303[1]	56,287[1]	518,876[1]		
Curbstone	—	—	—	—		
Paving blocks	—	—	—	—		
Chemical and metallurgical						
Cement plants, foreign	1,422,403	1,702,774	1,383,661	1,532,909		
Lining, open-hearth furnaces	392,930	485,922	401,451	526,296		
Flux in iron and steel furnaces	1,358,325	1,854,543	1,166,267	1,695,822		
Flux in nonferrous smelters	23,828	23,426	52,686	51,806		
Glass factories	206,203	839,466	241,968	1,138,389		
Lime kilns, foreign	273,835	589,346	321,418	798,522		
Pulp and paper mills	295,410	1,049,783	351,488	1,495,021		
Sugar refineries	69,749	196,024	63,150	206,326		
Other chemical uses	404,427	986,600	373,253	1,305,318		

Table 1 (concl'd)

	1973		1974		1975p	
	(short tons)	($)	(short tons)	($)	(short tons)	($)
Pulverized stone						
Whiting (substitute)	15,040	299,821	12,738	345,546		
Asphalt filler	58,251	255,068	76,165	298,255		
Dusting, coal mines	8,048	78,548	4,443	46,439		
Agricultural purposes and fertilizer plants	809,033	3,038,780	852,105	3,561,939		
Other uses	851,991	1,734,450	647,248	1,554,945		
Crushed stone for manufacture of						
Artificial stone	52,999	326,300	51,103	258,765		
Roofing granules	180,510	3,540,810	235,986	4,591,140		
Poultry grit	31,863	321,163	64,011	428,439		
Stucco dash	27,693	722,650	29,907	816,015		
Terrazzo chips	13,494	288,949	11,964	422,778		
Rock wool	—	—	14,651	29,302		
Rubble and riprap	2,322,343	3,276,594	1,881,381	3,487,415		
Concrete aggregate	14,665,956	19,351,261	13,105,649	21,229,826		
Asphalt aggregate	5,209,403	7,159,219	7,904,334	13,661,520		
Road metal	37,579,035	48,291,629	35,161,280	53,705,056		
Railroad ballast	3,962,834	5,082,203	6,255,105	10,000,079		
Other uses	21,882,182	23,754,820	31,493,336	50,150,999		
Total	92,274,188	128,692,603	102,330,926	177,207,078		

Source: Statistics Canada.
[1] Includes flagstone, curbstone, paving blocks, etc.
p Preliminary; — Nil.

Brinex has continued to investigate the feasibility of an industrial mineral complex based on high-calcium limestone.

In Nova Scotia, limestones occur in the central and eastern parts of the province in thin, tilted lenses typical of deposits in Atlantic Canada and in contrast to deposits of much greater thickness and areal extent in central Canada.

Mosher Limestone Company Limited quarries a dolomitic limestone at Upper Musquodoboit, Nova Scotia. Pulverized material is sold for agricultural use throughout the Atlantic provinces. Sydney Steel Corporation (Sysco) produces a high-calcium, fossiliferous limestone at Irish Cove, Nova Scotia, and a high-purity dolomite at Frenchvale, Nova Scotia, for use in the Sydney steel plant. Studies to determine the viability of a lime manufacturing plant in the Sydney area have been made in connection with incorporation of a basic oxygen process at the Sysco plant. Calpo Limited continues to supply sized, high-calcium limestone from an area near Antigonish Harbour to Scott Paper Limited at Abercrombie, and Canada Cement Lafarge Ltd. obtains limestone for portland cement manufacture on site at its Brookfield location.[6]

In New Brunswick, limestone is quarried at three locations — Brookville, Elm Tree and Havelock — for use as a crushed stone, as an aggregate, or for agricultural application. Brookville Manufacturing Company, Limited, Saint John, following an expansion program over the past four years, is now the largest supplier of coarse aggregate in southern New Brunswick and the company also supplies agricultural limestone. Havelock Processing Ltd. has expanded its plant to offer a range of products including washed, crushed and sized aggregates for asphalt and concrete application and finely pulverized filler material. Havelock Lime Works Ltd. produces high-calcium lime at Havelock[7] and Canada Cement Lafarge Ltd. uses limestone at its Havelock plantsite in the production of portland cement.[6]

Granite. Occurrences of granites in the Atlantic region have been described by Carr.[8] Current operations in Nova Scotia are at Nictaux, Shelburne and Erinville. A grey granite is produced from three operations near Nictaux and from one quarry at Shelburne for use mainly in the monument industry. A black granite from Shelburne and a diorite from Erinville are used similiarly. Quartzitic rock referred to as "bluestone" is quarried at Lake Echo, north of Dartmouth, for use as facing stone. Crushed quartzite for use as an aggregate is produced at a number of locations in Halifax County. At Folly Lake in Colchester County a diorite rock is quarried, mainly for use as railway ballast.

Granites are quarried intermittently from a number of deposits within New Brunswick to obtain stone of required colour and texture for specific application. A red, fine- to medium-grained granite is quarried near St. Stephen, and fine-grained, pink, grey and blue-grey granites are available in the Hampstead (Spoon Island) district. In the Bathurst area, a brown-to-grey, coarse-grained granite is quarried upon demand, as is a salmon-coloured, medium-grained granite near Antinouri Lake, and a black, ferromagnesian rock in the Bocabec River area. Red granite is available in the St. George district. Granite for use as a crushed stone is produced near Fredericton and near Moncton.

Sandstone. A medium-grained, buff sandstone is quarried at Wallace, Nova Scotia, for use as heavy riprap and for dimension stone applications. Recently, considerable tonnages were used in the reconstruction of the fortress at Louisbourg. Small deposits in many parts of the province are quarried periodically for local use.

In New Brunswick, a red, fine- to medium-grained sandstone has been quarried in Sackville for use in construction of buildings on the Mount Allison University campus. Deposits are exploited from time to time throughout Kent and Westmorland counties for local projects and for highway work.

Table 2. Canada, production (shipments) of limestone, 1973-74

	1973		1974	
	(short tons)	($)	(short tons)	($)
By province				
Newfoundland	181,881	103,223	441,126	1,207,867
Nova Scotia	230,278	638,694	195,020	500,397
New Brunswick	575,446	1,733,956	787,347	2,004,076
Quebec	40,481,174	45,781,950	41,699,243	61,302,087
Ontario	33,938,185	46,229,334	32,754,740	52,924,702
Manitoba	625,282	1,016,676	732,310	1,369,320
Alberta	151,216	803,960	156,455	871,158
British Columbia	2,474,910	4,009,168	3,445,133	7,438,093
Canada	78,658,372	100,316,961	80,211,374	127,617,700
By use				
Building stone				
Rough	12,539	168,045	36,803	574,916
Dressed	—	—	—	—
Monumental and ornamental				
Rough	1,152	43,512	780	27,220
Dressed	—	—	—	—
Flagstone	—	—	5,919[1]	141,598[1]
Curbstone	—	—	—	—
Paving blocks	—	—	—	—
Chemical and metallurgical				
Cement plants, foreign	1,362,067	1,568,828	1,325,176	1,402,399
Lining, open-hearth furnaces	392,930	485,922	401,451	526,296
Flux, iron and steel furnaces	1,358,325	1,854,543	1,165,556	1,681,602
Flux, nonferrous smelters	23,828	23,426	52,686	51,806
Glass factories	206,203	839,466	241,968	1,138,389
Lime kilns, foreign	273,835	589,346	321,418	798,522
Pulp and paper mills	284,744	983,050	340,915	1,429,249
Sugar refineries	69,749	196,024	63,150	206,326
Other chemical uses	374,239	896,037	373,253	1,305,318
Pulverized stone				
Whiting substitute	14,240	283,897	12,738	345,546
Asphalt filler	51,265	235,109	71,100	282,200
Dusting coal mines	8,048	78,548	4,443	46,439
Agricultural purposes and fertilizer plants	785,833	2,962,503	777,221	3,242,800
Other uses	850,133	1,712,277	643,288	1,487,258

Table 2 (concl'd)

	1973		1974	
	(short tons)	($)	(short tons)	($)
Crushed stone for				
Artificial stone	4,235	72,794	26,850	86,400
Roofing granules	25,200	69,434	52,372	307,661
Poultry grit	23,616	180,355	60,678	402,265
Stucco dash	3,071	61,995	20,253	696,547
Terrazzo chips	–	–	–	–
Rock wool	–	–	14,651	29,302
Rubble and riprap	728,706	1,066,080	961,137	2,118,434
Concrete aggregate	13,321,982	16,112,325	10,243,449	14,480,848
Asphalt aggregate	4,012,124	4,978,535	4,947,590	7,987,737
Road metal	34,739,335	44,181,407	28,301,668	41,695,637
Railroad ballast	2,671,820	2,327,185	4,800,112	6,939,082
Other uses	17,059,153	18,346,318	24,944,749	38,185,903
Total	78,658,372	100,316,961	80,211,374	127,617,700

Source: Statistics Canada.
[1]Includes flagstone, curbstone, paving blocks, etc.
– Nil.

Quebec. *Limestone.* Limestone occurs in the St. Lawrence and Ottawa river valleys and in the Eastern Townships. Other major deposits in the province are located in the Lac Saint-Jean – Saguenay River area and in the Gaspé region. The limestones range geologically from Precambrian to Carboniferous and vary widely in purity, colour, texture and chemical composition.[2]

Quebec Bureau of Statistics listed 76 operating limestone properties in 1974,[9] exclusive of portland cement and lime producers. Quarries are located near major market areas such as Montreal, Quebec City, Sherbrooke, Ottawa-Hull and Trois-Rivières and supply crushed stone to the construction industry, mainly for use in concrete and asphalt and as highway subgrade.

The pulp and paper, metallurgical and agricultural industries use substantial quantities of limestone. At Kilmar, in western Quebec, Dresser Industries Canada, Ltd., formerly Canadian Refractories Limited, mines a magnesite – dolomite ore from which it produces refractory-grade magnesia and magnesia products.

Portland cement was produced in 1975 by five companies in Quebec with a combined annual capacity of about 5.1 million tons, from a total of seven plants.[6] Four companies produce lime at four locations within the province.[7]

Limestone blocks and other shapes are produced for the construction trade in the Montreal region and at various locations throughout the province as the need arises. Marble has been produced in the Stukely and Philipsburg areas. Nine operations are listed by the Quebec Bureau of Statistics.[9]

Granite. Nearly 60 per cent of Canada's granite production comes from Quebec from long-established operations in two general regions – one north of the St. Lawrence and Ottawa rivers, including the Lac Saint-Jean area; and one south of the St. Lawrence River. Precambrian rocks contain granites of various colours, compositions and textures. Quebec Bureau of Statistics listed 59 granite producers in 1974[9], while the Quebec Department of Natural Resources indicated that 24 plants were processing granite as building or ornamental stone.[10] Many areas underlain by granite are too remote from transportation and markets to be economically attractive.

Sandstone. There are far fewer sandstone-producing operations in Quebec than there are producers of limestones and granites. Of 14 operations producing from sandstone resources only two are marketing flagstone and construction blocks, the rest are supplying crushed stone for general use as aggregate.[9,10]

Ontario. *Limestone.* Although limestones in Ontario range from Precambrian through Devonian, the major production comes from Ordovician, Silurian and Devonian deposits.[11,12] Of particular importance are the limestones and dolomites from the following geological sequences: the Black River and Trenton formations, extending from the lower end of Georgian Bay across southern Ontario to Kingston; the Guelph-Lockport Formation, extending from Niagara Falls to the Bruce Peninsula and forming the Niagara Escarpment; and the Middle Devonian limestone extending from Fort Erie through London and Woodstock to Lake Huron. Production of building stone, fluxstone and crushed aggregate from the limestones of these areas normally

Table 3. Canada, production (shipments) of marble, 1973-74

	1973		1974	
	(short tons)	($)	(short tons)	($)
By provinces				
Quebec	256,858	854,726	369,758	1,257,022
Ontario	9,662	252,474	8,865	361,620
Total, Canada	266,520	1,107,200	378,623	1,618,642
By use				
Building stone				
Rough	—	—	—	—
Dressed	—	—	—	—
Chemical process stone				
Flux in iron and steel furnaces	—	—	711	14,220
Pulp and paper mills	10,666	66,733	10,573	65,772
Other uses	30,188	90,563	—	—
Pulverized stone				
Whiting	800	15,924	—	—
Agricultural purposes and fertilizer plants	23,200	76,277	74,884	319,139
Other uses	1,858	22,173	3,785	65,937
Crushed stone				
For manufacture of artificial stone	48,764	253,506	24,253	172,365
Roofing granules	2,490	24,892	2,523	33,476
Poultry grit	480	4,801	—	—
Stucco dash	1,297	17,257	6,109	28,688
Terrazzo chips	13,494	288,949	11,964	422,778
Rubble and riprap	1,810	23,840	466	14,585
Concrete aggregate	—	—	—	—
Railroad ballast	103,557	188,077	—	—
Road metal	—	—	158,939	356,267
Other uses	27,916	34,208	84,416	125,415
Total	266,520	1,107,200	378,623	1,618,642

Source: Statistics Canada.
— Nil.

accounts for over 90 per cent of total stone production in Ontario.

Marble is widely distributed over southeastern Ontario and, according to the Ontario Ministry of Natural Resources reports, underlies as much as 100 square miles.[13]

Legislation now in effect in Ontario controls the development, operation and rehabilitation of existing pits and quarries, designates areas in which such operations may be started and provides for regulated sequential land use. The necessity for an advance assessment of the total impact of all developments affecting land use is recognized in the total legislative package. Complications arise, however, because of the number of government levels implementing and administrating the legislation. In early 1976 the Ministry of Natural Resources established a "Mineral Aggregate Working Party" bringing together representatives of the provincial and municipal governments, aggregate producers, the Conservation Council of Ontario and the Niagara Escarpment Commission. The Working Party will formulate, for consideration of Cabinet, a mineral aggregate resource management policy for Ontario that will include, where necessary, revisions to the Pits and Quarries Control Act. Mineral Aggregate Studies have been done over three major areas of Ontario; central, east and south, as part of a provincial program to determine the future availability of sand, gravel and crushed stone.

During 1975 portland cement was produced by four companies at a total of six locations in Ontario,[6] while eight companies operated a total of ten lime-producing facilities in the province.[7]

Table 4. Canada, production (shipments) of granite, 1973-74

	1973		1974	
	(short tons)	($)	(short tons)	($)
By province				
Newfoundland	36,230	234,614	19,889	133,314
Nova Scotia	400	11,900	780	13,850
New Brunswick	1,866,250	3,415,700	2,166,414	4,299,491
Quebec	3,431,441	7,333,608	8,627,924	18,221,692
Ontario	1,574,389	5,994,901	1,679,068	7,254,888
Manitoba	—	—	1,718,203	2,015,133
British Columbia	1,255,358	2,808,582	1,098,737	2,431,403
Total, Canada	8,164,068	19,799,305	15,311,015	34,369,771
By use				
Building stone				
Rough	17,671	704,529	19,193	716,928
Dressed	—	—	—	—
Monumental and ornamental				
Rough	28,802	1,378,882	30,326	1,303,321
Dressed	—	—	—	—
Flagstone[1]	9,849	127,298	10,716	177,116
Curbstone	—	—	—	—
Lining open-hearth furnaces	—	—	—	—
Chemical uses				
Pulp and paper mills	—	—	—	—
Pulverized stone				
Asphalt filler	6,986	19,959	5,065	16,055
Other pulverized uses	—	—	—	—
Crushed stone				
For artificial stone	—	—	—	—
Roofing granules	147,955	3,431,892	173,668	4,228,141
Poultry grit	6,539	128,221	708	11,080
Stucco dash	23,325	643,398	3,545	90,780
Rubble and riprap	1,589,214	2,174,588	915,209	1,347,553
Concrete aggregate	821,112	1,703,061	2,071,585	4,479,555
Asphalt aggregate	815,771	1,466,770	2,495,598	4,789,302
Road metal	1,960,596	2,843,398	4,916,683	8,293,473
Railroad ballast	1,012,013	2,286,231	1,148,563	2,480,388
Other uses	1,724,235	2,891,078	3,520,156	6,436,079
Total	8,164,068	19,799,305	15,311,015	34,369,771

Source: Statistics Canada.
[1]Includes flagstone, curbstone, paving blocks, etc.
— Nil.

Granite. Granites occur in northern, northwestern and southeastern Ontario.[14] Few deposits have been exploited for the production of building stone because the major consuming centres are in southern and southwestern Ontario where ample, good-quality limestones and sandstones are readily available for building. The areas most active in granite building stone production have been the Vermilion Bay area near Kenora, the River Valley area near North Bay, and the Lyndhurst-Gananoque area in southeastern Ontario. Rough building blocks were quarried from a gneissic rock near Parry Sound, while at Havelock a massive red-granite rock was quarried.

Sandstone. Sandstone quarried near Toronto, Ottawa and Kingston has been used widely in Ontario as building stone.[15] Production is currently from the Limehouse-Georgetown-Inglewood district where Medina sandstone is quarried, and from the Kingston area where Potsdam sandstone is quarried. Medina sandstones vary from grey, through buff and brown to red, and some are mottled. They are fine- to medium-grained. The Potsdam stone is medium-grained; the colour ranges from grey-white through salmon-red to purple, and it can also be mottled. Current uses are as rough building stone, mill blocks from which sawn pieces are obtained, ashlar, flagstone and as a source of silica for ferrosilicon and glass.

Table 5. Canada, production (shipments) of sandstone, 1973-74

	1973		1974	
	(short tons)	($)	(short tons)	($)
By provinces				
Newfoundland	176,200	633,700	205,811	690,818
Nova Scotia	582,250	1,082,278	1,470,000	4,071,621
New Brunswick	314,581	336,794	169,008	271,006
Quebec	1,685,139	3,251,487	2,536,015	4,875,677
Ontario	17,091	393,024	17,000	374,990
Alberta	56	975	120	3,305
British Columbia	—	—	—	—
Total, Canada	2,775,317	5,698,258	4,397,954	10,287,417
By use				
Building stone				
Rough	25,753	623,183	30,789	726,950
Dressed	—	—	—	—
Flagstone[1]	50,637	397,005	39,652	200,162
Curbstone	—	—	—	—
Paving blocks	—	—	—	—
Pulverized stone				
Asphalt filler	—	—	—	—
Agricultural purposes and fertilizer plants	—	—	—	—
Crushed stone				
For artificial stone	—	—	—	—
Roofing granules	4,865	14,592	7,423	21,862
Poultry grit	1,228	7,786	2,625	15,094
Terrazzo chips	—	—	—	—
Rubble and riprap	3,241	6,086	4,579	7,097
Concrete aggregate	484,045	1,142,388	751,055	1,698,767
Asphalt aggregate	381,508	713,914	461,146	884,481
Road metal	879,104	1,266,824	1,783,990	3,359,679
Railroad ballast	175,444	280,710	306,430	580,609
Other uses	769,492	1,245,770	1,010,265	2,792,716
Total	2,775,317	5,698,258	4,397,954	10,287,417

Source: Statistics Canada.
[1]Includes flagstone, curbstone, paving blocks, etc.
— Nil.

Table 6. Canada, production (shipments) of shale, 1973-74

	1973		1974	
	(short tons)	($)	(short tons)	($)
By province				
Newfoundland	—	—	13,000	12,000
Quebec	2,301,386	1,237,446	1,897,436	2,582,749
Alberta	9,372	6,000	23,479	17,633
British Columbia	99,153	527,433	98,045	701,166
Total, Canada	2,409,911	1,770,879	2,031,960	3,313,548

Table 6 (concl'd)

	1973		1974	
	(short tons)	($)	(short tons)	($)
By use				
Chemical and metallurgical				
Cement plants, foreign	60,336	133,946	58,485	130,510
Pulverized stone				
Other uses	—	—	175	1,750
Crushed stone				
Rubble and riprap	9,372	6,000	—	—
Concrete aggregate	38,817	393,487	39,560	570,656
Road metal	—	—	—	—
Railroad ballast	—	—	—	—
Other uses	2,301,386	1,237,446	1,933,740	2,610,632
Total	2,409,911	1,770,879	2,031,960	3,313,548

Source: Statistics Canada.
— Nil.

Table 7. Canada, production (shipments) of stone by types, 1965-74

	Granite		Limestone		Marble		Sandstone	
	(short tons)	($)	(short tons)	($)	(short tons)	($)	(short tons)	($)
1965	7,829,220	16,569,762	62,178,833	69,974,005	78,440	1,049,264	4,172,981	5,328,404
1966	19,598,325	25,423,394	69,760,441	77,431,007	157,789	1,190,592	5,202,281	5,949,172
1967	19,876,638	29,016,622	57,155,517	66,062,095	191,286	1,093,024	6,350,611	7,103,735
1968	16,654,735	23,310,531	54,538,796	65,619,953	165,007	637,845	4,267,391	5,136,658
1969	5,399,812	15,832,160	59,610,356	67,219,003	85,848	390,599	2,275,996	4,203,388
1970	4,837,239	15,231,891	57,896,297	67,563,790	61,835	350,903	2,328,957	4,133,708
1971	4,748,801	13,316,799	65,023,606	75,838,878	176,431	561,124	3,305,782	5,895,309
1972	5,341,028	14,765,335	70,752,120	81,697,564	317,170	895,653	3,502,306	5,195,048
1973	8,164,068	19,799,305	78,658,372	100,316,961	266,520	1,107,200	2,775,317	5,698,258
1974	15,311,015	34,369,771	80,211,374	127,617,700	378,623	1,618,642	4,397,954	10,287,417

	Shale		Slate		Total	
	(short tons)	($)	(short tons)	($)	(short tons)	($)
1965	2,338,460	1,837,492	160,171	88,094	76,758,105	94,847,021
1966	1,103,218	974,544	—	—	95,822,054	110,968,709
1967	433,256	612,796	—	—	84,007,308	103,888,272
1968	313,838	953,088	—	—	75,939,767	95,658,075
1969	105,000	541,112	—	—	67,477,012	88,186,262
1970	198,512	695,458	—	—	65,322,840	87,975,750
1971	260,222	924,963	—	—	73,514,842	96,537,073
1972	289,900	772,555	—	—	80,202,524	103,326,155
1973	2,409,911	1,770,879	—	—	92,274,188	128,692,603
1974	2,031,960	3,313,548	—	—	102,330,926	177,207,078

Source: Statistics Canada.
— Nil.

Western provinces. *Limestone.* From east to west through the southern half of Manitoba rocks of the following geological ages are represented: Precambrian, Ordovician, Silurian, Devonian and Cretaceous. Limestones of commercial importance occur in the three middle classifications and range from magnesian limestone through dolomite to high-calcium limestones.[2,16] Although building stone does not account for a large percentage of total limestone produced, the best known of the Manitoba limestones is Tyndall Stone, a mottled dolomitic limestone often referred to as "tapestry" stone. It is widely accepted as an attractive building stone, and is quarried at Garson, Manitoba, about 30 miles northeast of Winnipeg.

Limestone from Moosehorn, 100 miles northwest of Winnipeg, and from Mafeking, 25 miles east of the Saskatchewan border and 100 miles south of The Pas, is transported to Manitoba and Saskatchewan centres for use in the metallurgical, chemical, agricultural and construction industries. Limestone from Steep Rock and from Lily Bay is used by cement manufacturers in Winnipeg, and limestone from Faulkner is now being used by the lime plant at Spearhill. The possibility of utilizing marl, an unconsolidated calcareous material, from deposits in the Sturgeon Lake region of Saskatchewan in the pulp, and paper, cement, and lime industries has been investigated. Marl from a deposit 40 miles north of Edmonton is being used as raw material in cement manufacture.[6,7]

The eastern ranges of the Rocky Mountains contain limestone spanning the geological ages from Cambrian to Triassic, with major deposits in the Devonian and Carboniferous systems in which a wide variety of types occurs.[17] In southwestern Alberta, high-calcium limestone is mined at Exshaw, Kananaskis and Crowsnest, chiefly for the production of cement and lime, for metallurgical and chemical uses, and for use as a crushed stone. Similar uses are made of limestone quarried at Cadomin, near Jasper.[6,7]

In British Columbia, large volumes of limestone are mined each year for cement and lime manufacture, for use by the pulp and paper industry and for various construction applications.[6,7] A large amount is exported to the northwestern United States for cement and lime manufacture. Four companies mined limeStone on Texada Island, with the entire output being

Table 8. Canada, stone imports and exports, 1973-75

	1973		1974		1975^p	
	(short tons)	($)	(short tons)	($)	(short tons)	($)
Exports						
Building stone, rough	16,509	932,000	12,812	777,000	12,797	974,000
Crushed limestone, limestone refuse	1,690,755	2,426,000	1,343,907	2,254,000	1,342,135	2,417,000
Stone crude, nes	382,860	1,010,000	514,859	1,502,000	318,456	976,000
Natural stone, basic products	. .	1,946,000	. .	1,351,000	. .	1,776,000
Total	2,090,124	6,314,000	1,871,578	5,884,000	1,673,388	6,143,000
Imports						
Building stone, rough	10,912	528,000	14,625	749,000	20,824	953,000
Crushed limestone, limestone refuse	2,341,659	3,741,000	2,783,546	5,161,000	3,617,566	6,963,000
Crushed stone including stone refuse, nes	60,458	1,984,000	100,523	2,796,000	93,270	3,537,000
Stone crude, nes	1,519	153,000	1,975	133,000	2,246	163,000
Granite, rough	19,951	1,127,000	14,420	958,000	31,443	1,449,000
Marble, rough	5,464	680,000	9,979	1,363,000	6,574	899,000
Shaped or dressed granite	. .	345,000	. .	1,721,000	. .	1,375,000
Shaped or dressed marble	. .	964,000	. .	1,241,000	. .	1,885,000
Natural stone basic products	. .	410,000	. .	646,000	. .	584,000
Total	2,439,963	9,932,000	2,925,068	14,768,000	3,771,923	17,808,000

Source: Statistics Canada.
^{p}Preliminary; . . Not available; nes Not elsewhere specified.

Table 9. Value of construction in Canada, 1974-76

	1974[1]	1975[2]	1976[3]	Change 1975-76
	(millions of dollars)			(%)
Building construction				
Residential	8,460.7	8,718.6	10,425.4	19.6
Industrial	1,532.4	1,394.8	1,416.5	1.6
Commercial	2,969.1	3,518.8	3,293.5	-6.4
Institutional	1,382.7	1,539.3	1,626.4	5.7
Other building	900.4	1,177.4	1,273.3	8.2
Total	15,245.3	16,348.9	18,035.1	10.3
Engineering construction				
Marine	214.5	212.4	222.6	4.8
Highways, aerodromes	2,136.9	2,620.3	2,800.5	6.9
Waterworks, sewage systems	1,078.5	1,264.0	1,369.7	8.4
Dams, irrigation	111.2	120.1	124.2	3.4
Electric power	1,845.6	2,584.5	2,908.4	12.5
Railway, telephones	1,039.9	1,201.4	1,341.5	11.7
Gas and oil facilities	1,709.8	1,964.1	2,428.7	23.7
Other engineering	1,311.4	1,817.7	2,218.2	22.0
Total	9,447.8	11,784.5	13,413.8	13.8
Total construction	24,693.1	28,133.4	31,448.9	11.8

Source: Statistics Canada.
[1]Actual; [2]Preliminary; [3]Forecast.

moved by barge to Vancouver and the State of Washington. Deposits on Aristazabal Island have recently been developed for the export market. Other operations at Terrace, Clinton, Westwold, Popkum, Dahl Lake, Doeye River and Cobble Hill produced stone for construction and filler use, and for cement manufacture.[18] Periodically, interest is revived in the possible use of travertine from a British Columbia source.

Granite. In Manitoba, at Lac du Bonnet northeast of Winnipeg, a durable, red granite is quarried for building and monumental use. Grey granite located east of Winnipeg near the Ontario border is a potential source of building stone.

In British Columbia a light-grey to blue-grey, even-grained granodiorite of medium texture is available from Nelson Island. An andesite has been quarried at Haddington Island, off the northeast coast of Vancouver Island, for use as a building stone.

Sandstone. Sandstone for building and ornamental uses, quarried near Banff, Alberta is hard, fine-grained, medium-grey and is referred to as "Rundal Stone".

The environment

There is justifiable concern for the future development, operation and rehabilitation of pits and quarries in all locations, especially in and near areas of urban development. Rehabilitation of stone quarries for subsequent land use is generally more difficult and costly than rehabilitation of gravel pits.

Although an open-pit mining operation close to residential areas is seldom desirable, nonrenewable mineral resources must be fully and wisely utilized. Where urban sprawl has been unexpectedly rapid, conflicts for land use can materialize, and potential sources of raw mineral materials for the construction industry can be overrun. Master plans for land use are required to co-ordinate all phases of development so that mineral exploitation is part of the urban growth pattern.

Markets, outlook and trade

Limestones are widely distributed in Canada and generally are available in sufficient quantity and with such chemical or physical specifications that long transportation hauls are unnecessary. Limestone products are low-priced commodities and only rarely, when a market exists for a high-quality, specialized product such as white portland cement or a high-purity extender, are they beneficiated or moved long distances. Provided the specifications are met, the nearest source is usually considered, regardless of provincial or national boundaries.

Table 10. Canada, value of construction work performed by principal type of construction, by industry, 1973-76

Industry	1973[1]			1974[1]			1975[2]			1976[3]		
	Building	Engineering	Total	Building	Engineering	Total	Building	Engineering	Total	Building	Engineering	Total
	(millions of dollars)											
Agriculture and fishing	312	169	481	393	212	605	470	254	724	501	270	771
Forestry	15	88	103	26	108	134	18	103	121	17	115	132
Mining, quarrying, oil wells	220	1,249	1,469	264	1,553	1,817	303	1,932	2,235	359	2,679	3,038
Construction	70	1	71	81	1	82	92	1	93	102	1	103
Manufacturing	844	419	1,263	1,184	586	1,770	1,089	795	1,884	1,060	920	1,980
Utilities	282	2,891	3,173	430	3,343	3,773	491	4,326	4,817	626	4,818	5,444
Trade	355	9	364	468	14	482	401	20	421	404	19	423
Finance, insurance, real estate	1,059	102	1,161	1,314	112	1,426	1,466	102	1,568	1,444	136	1,580
Commercial services	333	2	335	489	4	493	869	12	881	562	9	571
Housing	7,165	—	7,165	8,461	—	8,461	8,719	—	8,719	10,425	—	10,425
Institutional services	1,040	9	1,049	1,207	11	1,218	1,310	18	1,328	1,386	13	1,399
Government departments	710	2,830	3,540	928	3,504	4,432	1,121	4,221	5,342	1,149	4,434	5,583
Total	12,405	7,769	20,174	15,245	9,448	24,693	16,349	11,784	28,133	18,035	13,414	31,449

Source: Statistics Canada.
[1]Actual; [2]Preliminary; [3]Forecast.
— Nil.

Over 70 per cent of Canada's annual production of limestone is used as crushed stone. This includes about 50 per cent used as road metal (broken, screened stone for macadam roads), about 20 per cent as concrete aggregate and about 2 per cent as railroad ballast.

Some major uses in the chemical field are: neutralization of acid waste liquors, extraction of aluminum oxide from bauxite, manufacture of soda ash, calcium carbide, calcium nitrate and carbon dioxide; in pharmaceuticals, as a disinfectant, in the manufacture of dyes, rayons, paper, sugar and glass; and in the treatment of water. Dolomitic limestone is used in the production of magnesium chloride and other magnesium compounds.

Limestone is used in the metallurgical industries as a fluxing material where it combines with impurities in ore to form a fluid slag that can be separated from molten metal. Calcium limestones are used in open-hearth steel manufacture, whereas both calcium limestones and dolomitic limestones are used as a flux in the production of pig iron in blast furnaces.

Limestone is used extensively as a filler or an extender and, where quality permits, as whiting. In such applications both physical and chemical properties are important. Specifications vary widely but, in general, a uniform, white material passing 325 mesh would meet the physical requirements. Whiting is used in ceramic bodies, plastics, floor coverings, insecticides, paper, wood putty, rubber, paints and as a filler in many other commodities. In paint manufacture, the material may be used as a pigment extender.

Agricultural limestone is used to control soil acidity and to add calcium and magnesium to the soil. Limestone and lime are used as soil stabilizers, particularly on highway construction projects.

Dolomite is the source of magnesium metal produced at Haley, Ontario; the company also uses a high-calcium lime from southeastern Ontario in the production of calcium metal. Dead-burned dolomitic limestone for use as a refractory is produced at Dundas, Ontario, by Steetley of Canada (Holdings) Limited.

Limestone from deposits in coastal areas of British Columbia is mined, crushed, loaded on barges of up to 20,000 tons capacity, and transported as much as 400 miles to consuming centres along the west coast in both Canada and the United States. One Canadian company, Domtar Chemicals Limited, manufactures lime at Tacoma, Washington, using limestone from Texada Island.

Crushed stone will continue to compete with sand and gravel for major markets where the latter are scarce. Through vertical integration, large operations based on construction materials can, by mergers and acquisitions, obtain captive markets for their products in operating construction firms. Construction firms can also integrate backwards into the resource field.

The possibility of substitutes for aggregates is not likely to occur soon in Canada, although in countries where such resources are scarce other materials such as compressed garbage are being used. The use of lime or cement to stabilize soils could reduce the amount of aggregate fill required on some highway or railway projects.

Traditional markets for building stone have been lost to competitive building materials such as steel and concrete. Modern design and construction methods favour the flexibility offered by the use of steel and precast or cast-in-place concrete. For aesthetic qualities not available in other materials, rough or polished stone is used in many modern structures. Monumental stone continues to be in demand.

The present structure of the building stone industry in Canada is unlikely to change very soon. Recent efforts have been made on behalf of the industry to illustrate to contractors and architects the availability of a wide range of Canadian building stones and their adaptability in modern building design.

References

1. Parks, Wm. A., *Building and Ornamental Stones of Canada,* Canada Department of Mines, Mines Branch, Ottawa, Nos. 100, 203, 279, 388 and 452, Volume 1 (1912) to Volume V (1917) OUT OF PRINT.
2. Goudge, M.F., *Limestones of Canada,* Canada Department of Mines, Mines Branch, Ottawa, Nos. 733, 742, 755, 781, 811 Part 1, 1934 to Part V, 1946. OUT OF PRINT.
3. DeGrace, John R., *Limestone Resources of Newfoundland and Labrador,* Department of Mines and Energy, Mineral Development Division, St. John's, Newfoundland, Report 74-2, 1974.
4. Shea, F.S., Murray, D.A., *Limestones and Dolomites of Nova Scotia,* Department of Mines, Halifax, N.S., Part I, Bulletin No. 2, 1967 and Part II, Bulletin No. 2, 1975.
5. Hamilton, J.B., *"Limestone in New Brunswick",* Department of Natural Resources, Mineral Resources Branch, Fredericton, N.B., Mineral Resources Report No. 2, 1965.
6. Stonehouse, D.H., "Cement", *Canadian Minerals Yearbook, 1975,* Department of Energy, Mines and Resources, Mineral Development Sector, Ottawa.
7. Stonehouse, D.H., "Lime", *Canadian Minerals Yearbook, 1975,* Department of Energy, Mines and Resources, Mineral Development Sector, Ottawa.
8. Carr, G.F., *The Granite Industry of Canada,* Canada Department of Mines and Technical Surveys, Mines Branch, Ottawa, Ontario, No. 846, 1955.
9. *Directory of Mining Establishments,* Quebec, Bureau of Statistics Publication, 1974.
10. *Mining Industry in Quebec,* Department of Natural Resources, Quebec, 1974.
11. Hewitt, D.F., *The Limestone Industries of Ontario,* Ontario Department of Mines, Toronto, Industrial Mineral Circular No. 5, 1960.

12. Hewitt, D.F., Vos, M.A., *The Limestone Industries of Ontario,* Ministry of Natural Resources, Division of Mines, Toronto, Industrial Mineral Report No. 39, 1972.

13. Hewitt, D.F., *Building Stones of Ontario, Part III, Marble,* Ontario Department of Mines, Toronto, Industrial Mineral Report No. 16, 1964.

14. Hewitt, D.F., *Building Stones of Ontario, Part V, Granite and Gneiss,* Ontario Department of Mines, Toronto; Industrial Mineral Report No. 19, 1964.

15. Hewitt, D.F., *Building Stones of Ontario, Part IV, Sandstone,* Ontario Department of Mines, Toronto, Industrial Mineral Report No. 17, 1964.

16. Bannatyne, B.B., *High-Calcium Limestone Deposits of Manitoba,* Department of Mines, Resources and Environmental Management, Mineral Resources Division, Exploration and Geological Survey Branch, Winnipeg, Publication 75-1, 1975.

17. Holter, M.E., "Limestones Resources of Alberta, Transactions," *Canadian Institute of Mining and Metallurgy,* V. 76, 1971.

18. McCammon, J.W., Olsen, P.E., Robinson, W.C., Robinson, J.W., Dundas, D.M., British Columbia Department of Mines and Petroleum Resources, *Geology, Exploration and Mining in British Columbia, 1973.*

Tariffs

Canada

Item No.		British Preferential (%)	Most Favoured Nation (%)	General (%)	General Preferential (%)
29635-1	Limestone, not further processed than crushed or screened	free	free	25	free
30500-1	Flagstone, sandstone and all building stone, not hammered, sawn or chiselled	free	free	20	free
30505-1	Marble, rough, not hammered or chiselled	10	10	20	free
30510-1	Granite, rough, not hammered or chiselled	free	free	20	free
30515-1	Marble, sawn or sand rubbed, not polished	free	10	35	free
	GATT		5		
30520-1	Granite, sawn	free	7½	35	free
30525-1	Paving blocks of stone	free	7½	35	free
30530-1	Flagstone and building stone, other than marble or granite, sawn on not more than two sides	free	7½	35	free
30605-1	Building stone, other than marble or granite, sawn on more than two sides but not sawn on more than four sides	5	7½	10	5
30610-1	Building stone, other than marble or granite planed, turned, cut or further manufactured than sawn on four sides	7½	12½	15	7½
30615-1	Marble, not further manufactured than sawn, when imported by manufacturers of tombstones to be used exclusively in the manufacture of such articles, in their own factories	free	15	20	free
	GATT		free		
30700-1	Marble, nop	17½	17½	40	11½
30705-1	Manufacturers of marble, nop	17½	17½	40	11½
30710-1	Granite, nop	17½	17½	40	11½
30715-1	Manufacturers of granite, nop	17½	17½	40	11½
30800-1	Manufacturers of stone, nop	17½	17½	35	11½
30900-1	Roofing slate, per square of 100 square feet	free	free	75¢	free
30905-1	Granules, whether or not coloured or coated, for use in manufacture of roofing, including shingles and siding	free	free	25	free

United States

Item No.		On and after January 1, 1970	1971	1972
513.61	Granite, not manufactured, and not suitable for use as monumental, paving or building stone	free	free	free
514.11	Limestone, crude, not suitable for use as monumental, paving or building stone, per short ton	14¢	12¢	10¢
		(%)	(%)	(%)
513.21	Marble chips and crushed	7	6	5
514.91	Quartzite, whether or not manufactured	free	free	free
515.11	Roofing slate	17	15	12.5
515.14	Other slate	7	6	5
515.41	Stone, other, not manufactured and not suitable for use as monumental, paving or building stone	free	free	free

Sources: For Canada, the Custom Tariff and Amendments, Department of National Revenue, Customs and Excise Division. For United States, Tariff Schedules of the United States, Annotated (1976) T.C. Publication 749.
Note: Varying tariffs are in effect on the more-fabricated stone categories.
nop Not otherwise provided for.

Sulphur

G.H.K. PEARSE

Sulphur, one of the most important and versatile industrial raw materials, is widely distributed throughout the world in both elemental and combined forms. It has been used by man since antiquity and today all industries use sulphur in some form, principally as a processing and manufacturing reagent. More than half of the world's sulphur output is in elemental form, nearly all obtained from native sulphur deposits and sour natural gas. The remainder is recovered from pyrite and smelter stack gases, principally as sulphuric acid, in which form 87 per cent of all sulphur is consumed. Fertilizer manufacture accounts for about half of all sulphur consumed, followed by chemicals, pigments and pulp and paper as the next largest consuming sectors.

World sulphur production in all forms at 51.5 million metric tons in 1975 was marginally lower than that of the previous year; a decline of 1.7 million metric tons in western world production was largely offset by an increase in production in the communist countries. World consumption declined about 5 per cent as the result of a 10 per cent western world decline, and a 9 per cent communist world increase, in consumption. Canada's total elemental sulphur sales in 1975 were 3.9 million tons*, 22 per cent less than in 1974. Sulphur stockpiles on the prairies were 16.1 million tons at year-end.

Slack demand, beginning in late 1974, continued throughout 1975. Despite this, price erosion was modest.

The Canadian sulphur industry

Canadian sulphur is obtained from three sources; elemental sulphur derived from sour natural gas and petroleum, sulphur recovered from smelter gases in the form of sulphuric acid and sulphur contained in pyrite concentrates used in sulphuric acid manufacture. Minor tonnages of elemental sulphur are recovered as a byproduct of electrolytic refining of nickel sulphide matte, and a small quantity of liquid sulphur dioxide is produced from pyrites and smelter gases. In 1975, 93 per cent of Canadian sulphur shipments were in elemental form, nearly all from sour natural gas in western Canada. Canada has been the world's largest exporter of elemental sulphur since 1968.

Canadian elemental sulphur production from sour natural gas declined for the second consecutive year.

Hydrocarbon sources

Hydrocarbons contain sulphur in some form in at least minute amounts. Where the sulphur content is unacceptably high, as it is in many gas reservoirs in western Canada, it must be removed. Sulphur produced from hydrogen sulphide (H_2S), the dominant sulphur compound occurring in sour natural gas, is presently the most important source in Canada. Because of the need to strip highly corrosive and toxic hydrogen sulphide from gas prior to marketing, the elemental sulphur produced is an involuntary byproduct of natural gas operations.

Sulphur recovery in Canada from Athabasca oil sands and crude oil is comparatively minor at present and is virtually nil from coal. However, with ever-increasing energy requirements, and with stringent air pollution regulations coming into force, these vast sources of sulphur will, in the future, contribute substantially to world supply.

Sour natural gas

Although the H_2S content of sour gas fields ranges as high as 91 per cent by weight of the total raw gas in place, most of the producing fields contain from 1 to 20 per cent H_2S. The modified Claus process in one of its variants is used to recover sulphur from the sour natural gas. Briefly, the method is as follows: H_2S is extracted by absorption into a solution of one of the following: diethanolamine, monoethanolamine, hot potassium carbonate, or sulfinol. The solution is then heated in a stripper tower where H_2S is evolved. The H_2S passes into a furnace where a controlled air flow results in partial oxidation of H_2S to permit the following reactions:

*The long, or gross, ton of 2,240 pounds is used throughout unless otherwise stated.

Table 1. Canada, sulphur production and trade 1974-75

	9174		1975^p	
	(long tons)	($)	(long tons)	($)
Production				
Pyrite and pyrrhotite[1]				
Gross weight	48,178	. .	18,750	. .
Sulphur content	24,089	347,043	9,375	90,000
Sulphur in smelter gases[2]	652,845	9,812,515	695,536	10,417,000
Elemental sulphur[3]	4,953,568	68,555,657	3,999,107	89,190,000
Total sulphur content	5,630,502	78,715,215	4,704,018	99,697,000
Imports				
Sulphur crude or refined				
United States	30,850	1,241,000	14,109	911,000
France	43	5,000	—	—
Total	30,893	1,246,000	14,109	911,000
Exports				
Sulphur in ores (pyrite)				
United States	. .	648,000	. .	170,000
Total	. .	648,000	. .	170,000
Sulphuric acid and oleum (contained sulphur)				
United States	81,746	3,847,000	49,627	4,324,000
Other	8	2,000	7	4,000
Total	81,754	3,849,000	49,634	4,328,000
Sulphur crude or refined, nes				
United States	1,163,420	20,319,000	959,365	22,739,000
Italy	329,350	5,739,000	333,441	10,449,000
Belgium-Luxembourg	195,067	4,965,000	199,337	10,199,000
Australia	422,856	11,975,000	254,305	9,813,000
South Africa	257,069	5,489,000	184,426	8,752,000
Netherlands	199,344	3,573,000	170,196	6,565,000
Taiwan	402,259	10,782,000	191,895	5,738,000
India	108,963	1,512,000	119,919	5,392,000
South Korea	156,762	3,884,000	111,007	4,793,000
New Zealand	262,503	5,838,000	104,328	4,537,000
France	33,100	961,000	95,437	4,531,000
Brazil	110,545	1,571,000	117,416	3,289,000
People's Republic of China	14,056	95,000	64,045	2,953,000
Tunisia	25,938	830,000	39,501	2,303,000
Other	503,074	12,835,000	299,722	11,065,000
Total	4,184,306	90,368,000	3,244,340	113,118,000

Sources: Statistics Canada; Mineral Development Sector, Department of Energy, Mines and Resources, Ottawa.
[1]Producers' shipments of byproduct pyrite and pyrrhotite from the processing of metallic sulphide ores. [2] Sulphur in liquid SO_2 and H_2SO_4 recovered from the smelting of metallic sulphides and from the roasting of zinc-sulphide concentrates. [3]Producers' shipments of elemental sulphur produced from natural gas; also included are small quantities of sulphur produced in the refining of domestic crude oil and from the treatment of nickel-sulphide matte.
^p Preliminary; — Nil; . . Not available; nes Not elsewhere specified.

$2H_2S + 3O_2 \leftrightarrows 2H_2O + 2SO_2$

$2H_2S + SO_2 \leftrightarrows 2H_2O + 3S$

Gas from this furnace enters a condenser-converter series and a portion of liquid sulphur is removed from the vapour in each unit. Overflow gases then pass through another reaction furnace and the process is repeated until 95 per cent or more of the original sulphur has been removed. In large plants the tail gases are passed through a cleanup unit to increase recovery efficiency. The liquid sulphur is fed into an underground storage pit for pumping to outside storage blocks where the liquid cools and solidifies, or to liquid storage tanks for direct shipping to North American markets in liquid form. Alternatively, the liquid is fed into a slating plant where it is quenched in water on a special belt, subsequently breaking up into "slates".

Canada's first sour natural gas sulphur recovery plant came on stream in Alberta in 1951, and sulphur output in 1952 was 8,000 tons. In 1975, 44 plants were operating, including one in Saskatchewan and two in British Columbia with a combined daily capacity of 25,266 tons, up slightly from the previous year as a result of minor expansions to six existing plants and the addition to Westcoast Transmission Company Limited's Fort Lebson, B.C. plant of a 450-ton-a-day sulphur recovery unit. Production of elemental sulphur from natural gas in Alberta, as reported by the Alberta Energy Resources Conservation Board, was 6,406,342 tons, a decrease of 5.5 per cent from that of 1974. Production in 1975 in British Columbia was 59,870 tons and in Saskatchewan 2,289 tons. Total Canadian production for 1975 was 6,468,501 tons of elemental sulphur derived from sour gas.

Alberta sulphur sales were 3,771,021 tons in 1975, down 23 per cent from 1974. Despite this, the value of sales increased 28 per cent to $86,314,687 for the year. Alberta inventories stood at 16,130,820 tons at year-end. In 1975 British Columbia and Saskatchewan elemental sulphur sales were 37,922 tons and 2,500 tons, and inventories were 141,204 tons and 6,500 tons, respectively.

Canadian elemental sulphur productive capacity, having doubled between 1968 and 1972, reached a plateau in 1975 and output declined for the second consecutive year. Shell Canada Limited's sour gas discovery in the Rosevear area during the year may prove to be substantial. If so, it will be the first important find since the late 1960s. With a lag of three to four years between discovery and plant startup, a significant increment in sulphur capacity cannot be expected before 1980. Additional capacity scheduled for 1976 includes Sun Oil Company Limited's 82-ton-a-day Rosevear plant and Hudson's Bay Oil and Gas Company Limited's 73-ton-a-day Zama oil field plant which are scheduled for completion in mid-year, and Cities Service Canada Ltd's 19-ton-a-day Paddle River plant scheduled for September.

Pollution abatement guidelines for natural gas plants laid down in November 1971 by the Alberta government include: mandatory stack cleanup facilities and recovery efficiencies between 97 and 99 per cent, depending on acid gas quality, for plants rating over 1,000 tons a day; minimal stack cleanup or equipment with efficiency between 94 and 98 per cent for plants rated between 400 and 1,000 tons a day; at least a three-stage Claus unit or equivalent with efficiency between 92 and 96 per cent for 100- to 400-ton plants, and a two-stage Claus unit with recovery efficiency between 90 and 94 per cent for smaller plants. All plants were to have complied with this requirement by December 31, 1975.

Prior to 1974, all sulphur destined for offshore markets was railed to loading terminals at Vancouver, some 650 miles from processing plants. During the last two years higher sulphur prices permitted shipping via Churchill, Manitoba; Thunder Bay, Ontario and Quebec City, Quebec. Approximately 100,000 tons in each year were moved through these alternate ports. These ports could increase in importance with the recovery of sulphur markets, although Amoco Canada Petroleum Company Ltd. has discontinued shipments through Churchill indefinitely.

Athabasca oil sands

The Athabasca oil sands constitute a vast deposit of relatively unconsolidated sandstone impregnated with bitumen, covering some 30,000 square miles of northeastern Alberta. The estimated 300 billion barrels of recoverable oil in the formation contain about 2 billion tons of sulphur.

In late 1967, Great Canadian Oil Sands Limited (GCOS) completed the first commercial oil-sand extraction plant at a cost of $240 million. The ancillary sulphur recovery plant is designed to produce 300 tons of sulphur daily. Sulphur production was 74,000 tons in 1975, down 14 per cent from the previous year as a result of a maintenance shutdown and technical problems during the first half of the year. Shipments of sulphur from GCOS began in October 1974, and by year-end 30,000 tons had been shipped to Quebec City for offshore markets. Stockpiled sulphur at the plant site had reached 375,022 tons as of December 31st, 1974. Another project, that of Syncrude Canada Ltd., is under construction and is expected to be completed in 1978. It is designed to produce 125,000 barrels a day of synthetic crude oil and products. Petrofina Canada Ltd. may have a plant on stream by the early 1980's and overall development of the tar sands by 1985 is expected to result in a synthetic crude production of 400,000 barrels a day. This would yield about 700,000 tons of sulphur a year. Annual output by the year 2000, assuming a new plant every two years after 1985, could reach 3 million tons of sulphur.

Oil refineries

Some crude oils contain as much as 5 per cent sulphur, either as hydrogen sulphide or in other compounds. Domestic crudes generally contain less than 1 per cent

Table 2. Canada, sour gas sulphur extraction plants, 1975

Operating Company	Source Field or Plant Location	H_2S in Raw Gas	Daily Capacity
	(Alberta, except where noted)	(%)	(long tons)
Amerada Hess Corporation	Olds	11	280
Amoco Canada Petroleum	Bigstone Creek	19	376
Amoco Canada Petroleum	East Crossfield	34	1,710
Aquitaine Company of Canada	Rainbow Lake	4	140
Aquitaine Company of Canada	Ram River	9-35	4,100
Atlantic Richfield	Gold Creek		42
Saratoga Processing Company	Savannah Creek (Coleman)	13	377
Canadian Occidental	Taylor Flats, B.C.	3	325
Canadian Superior Oil	Harmattan-Elkton	53	482
Canadian Superior Oil	Lonepine Creek	12	150
CanDel Oil	Minnehik-Buck Lake		32
Chevron Standard	Kaybob South	19	3,050
Chevron Standard	Nevis	7	260
Gulf Oil Canada[1]	Nevis	3-7	290
Gulf Oil Canada	Pincher Creek	10	196
Gulf Oil Canada	Rimbey	1-3	326
Gulf Oil Canada	Strachan	10	960
Home Oil	Carstairs	1	58
Hudson's Bay Oil and Gas	Brazeau River	1	89
Hudson's Bay Oil and Gas	Caroline	1	18
Hudson's Bay Oil and Gas	Edson	2	285
Hudson's Bay Oil and Gas	Hespero (Sylvan Lake)	1	15
Hudson's Bay Oil and Gas	Kaybob South (1)	17	1,070
Hudson's Bay Oil and Gas	Kaybob South (2)	17	1,030
Hudson's Bay Oil and Gas	Lonepine Creek	10	280
Hundson's Bay Oil and Gas[1]	Sturgeon Lake South	10	96
Imperial Oil	Joffre		27
Imperial Oil	Quirk Creek		286
Imperial Oil	Redwater	3	29
Mobil Oil Canada	Wimborne	14	331
Petrofina Canada	Wildcat Hills	4	165
Petrogas Processing	Crossfield (Blazac)	31	1,840
Shell Canada	Burnt Timber Creek	8-5	187
Shell Canada	Innisfail	14	160
Shell Canada	Jumping Pound	3-5	430
Shell Canada	Simonette River	15	210
Shell Canada	Waterton	18-25	2,970
Steelman Gas	Steelman, Sask.	1	8
Texaco Exploration[2]	Bonnie Glen		15
Tenneco Oil & Minerals	Nordegg		41
Texasgulf Inc.	Okotoks	33	430
Texasgulf Inc.	Windfall	16	1,940
Westcoast Transmission	Fort Nelson, B.C.		700
Western Decalta	Turner Valley	4	30
Total daily rated capacity — December 31, 1975			25,266

Source: *Canadian Petroleum.*
[1] Plants increased capacity in 1974; [2] New plant in 1974.

sulphur. The sulphur may either be removed in the form of H_2S or treated to form nondeleterious disulphides. Recovery techniques employed during oil refining are similar to those used in the removal of sulphur from sour gas.

In Canada, sulphur is recovered from imported crudes at oil refineries in Nova Scotia, New Brunswick, Newfoundland and Quebec and from domestic crudes at oil refineries near Toronto, Sarnia, Winnipeg, Edmonton and Vancouver. Total sulphur output from refineries in 1975 was an estimated 160,000 tons, including 60,000 tons from Montreal refineries alone. This recovery represents only 20 per cent of total sulphur contained in the crude.

Coal and oil shales

Coke oven gases generally contain some hydrogen sulphide, the quantity dependent upon the sulphur content of the coal being carbonized. Ordinarily the H_2S is removed in "iron oxide boxes", but it can also be recovered and converted to elemental sulphur.

In response to the demand for increasing amounts of clean fuel, numerous research projects were initiated over the last few years with the aim of developing high quality, pollution-free gas from coal. Escalation of the energy crisis, particularly in the United States and Europe, brought about by Middle East oil supply cutbacks near the end of 1973, has given further impetus to gasification projects and oil shale studies. Annual sulphur recovery from these sources, largely in the United States, could reach 2 million tons by 1990 and 10 million tons by the end of this century. Although coal in western Canada is low in sulphur (less than 0.5 per cent), coal from the Maritimes is notably sulphurous. With more stringent pollution regulations coming into force, coal gasification may become the only way in which this energy source can be utilized in the future.

Metallic sulphide sources

In Canada, the use of metallic sulphides for their sulphur content dates back to 1866. Early operations consisted essentially of roasting pyrite for the direct manufacture of sulphuric acid. In the 1920s the use of base-metal smelter gases for the manufacture of byproduct H_2SO_4 began near Sudbury, Ontario and at Trail, British Columbia. Virtually all Canada's sulphur production was from metallic sulphides prior to 1951, when the first sour gas sulphur recovery plant was built. In 1975, metallic sulphides provided an estimated 685,000 tons of contained sulphur.

Smelter gases

Effluent gas from smelting of sulphide ores contains from 1 to 12 per cent sulphur dioxide (SO_2). Recovery of SO_2 includes processes for cleaning, purifying, cooling and concentrating. Concentrated SO_2 is then used directly for the manufacture of H_2SO_4 via the contact-acid process. As much as 170,000 tons (85,000 tons sulphur content) of SO_2 is produced for use as a processing agent in a variety of applications. Some SO_2 is used for the manufacture of oleum (fuming sulphuric acid, $H_2S_2O_7$). Production in 1975 was 675,500 tons of contained sulphur, little changed from the previous year. Proposed increments to smelter capacity and increased sulphur recovery efficiency presages a rapid growth in sulphuric acid output over the next 10 years.

Table 3. Proposed new plants for 1976

Operating Company	Location	Proposed Daily Rated Capacity (tons)
Cities Services Canada	Paddle River	19
Hudson's Bay Oil and Gas	Zama	73
Sun Oil Company	Rosevear	82

The largest sulphuric acid plant complex in Canada is that of Canadian Industries Limited (CIL) at Copper Cliff, Ontario. The company operates three acid plants that have a combined annual capacity of 900,000 tons of H_2SO_4 based on SO_2 gas from The International Nickel Company of Canada, Limited (Inco's) iron ore recovery plant. In addition, CIL has a liquid sulphur dioxide plant at Inco's nearby Copper Cliff smelter. Much of the acid produced at Copper Cliff is shipped by unit-train about 475 miles to CIL's fertilizer works near Sarnia, Ontario. The company owns a sulphuric acid depot at Niagara Falls, Ontario, which consists of a 60,000 short-ton storage tank and equipment for unloading unit-trains and loading tank cars and trucks. Acid from Copper Cliff is shipped directly to the facility via 56-car unit-trains.

Subsidiaries of Noranda Mines Limited produce smelter acid at three localities: Gaspé Copper Mines, Limited's 245,000-ton-a-year plant at Murdochville, Quebec; Brunswick Mining and Smelting Corporation Limited's 125,000-ton-a-year plant at Belledune, New Brunswick and Canadian Electrolytic Zinc Limited's zinc concentrate roasting facility at Valleyfield, Quebec, with a capacity of 120,000 tons a year. A proposed copper smelter and associated 100,000-ton-a-year sulphuric acid installation to be built at Noranda, Quebec has been shelved for the time being.

Cominco Ltd's sulphuric acid capacity at Trail, British Columbia, based on its lead-zinc smelter, was increased 30 per cent in 1975 to 490,000 tons a year with the replacement of the two older units by a single plant. Acid capacity at the company's Kimberley plant is 300,000 tons a year. Much of the acid produced is utilized by Cominco in the manufacture of fertilizers.

Allied Chemical Canada, Ltd. produces sulphuric acid from the roasting of zinc concentrates supplied under an agreement with Canadian Electrolytic Zinc whereby Allied retains the acid for its own use and delivers the zinc calcine to Canadian Electrolytic Zinc's nearby refinery.

Texasgulf Canada Ltd's Timmins, Ontario zinc plant has a sulphuric acid capacity of 200,000 tons a year. A planned expansion will raise acid output to 400,000 tons by 1978. A second stage, now deferred, was to have raised capacity to 560,000 tons by 1979. A proposed associated phosphate fertilizer works has been shelved.

Falconbridge Nickel Mines Limited has announced plans for the replacement of its blast furnaces with electric melting equipment and installation of fluid bed roasters. Acid capacity will be 325,000 tons a year upon completion in 1977.

Shipments of acid and oleum to the United States in 1975 contained 49,627 tons of sulphur, down 40 per cent from 1974. Small amounts were shipped elsewhere, mainly to the West Indies.

Pyrite and pyrrhotite

Pyrite and pyrrhotite concentrates produced as a byproduct of base-metal mining operations are sometimes marketed for their sulphur content. The distinction between the category of sulphur in pyrite and pyrrhotite, and that in smelter gases as used in this review is based upon the concept that, for example, although most of the acid production at Copper Cliff, Ontario is dependent upon the roasting of iron sulphides, the sulphur production is reported as smelter gases. However, in other instances the iron sulphide concentrates are sold and shipped for roasting elsewhere and are reported as pyrite and pyrrhotite production.

Noranda Mines Limited and Normetal Mines Limited have, over the years, shipped pyrite to acid plants, principally in the northeastern United States. Recent conversion to elemental sulphur feed resulted in a drastic reduction in pyrite usage. Noranda discontinued pyrite sales in 1973. Other companies are stockpiling pyrite concentrates pending development of future markets for this material. In 1975 Canada's pyrite and pyrrhotite shipments amounted to an estimated 18,750 tons of concentrates (9,375 tons contained sulphur) valued at $90,000.

Canada consumption and trade

In 1974 Canadian consumption of sulphur in all forms, as reported by consumers, amounted to about 1.5 million tons, of which 840,000 tons was elemental sulphur.

Canada remains the largest supplier of elemental sulphur to world markets despite a decline of nearly one million tons in exports in 1975 to 3.24 million tons.

Byproduct sulphur from western Canada has, over the years, penetrated much of the United States market. From the outset that country has been the principal destination for Canadian sulphur and presently accounts for about 30 per cent of Canadian exports. Sales to the United States were down 18 per cent from 1974. Shipments to Europe, which had almost quadrupled between 1971 and 1974 largely as a result of major increases in Dutch, British and Italian

Table 4. Canada, principal sulphur operations based on metallic sulphides, 1974

Operating Company	Plant Location	Raw Material	Annual Capacity 100% H_2SO_4	Annual Capacity Approx. S equiv.
			(long tons)	
Smelter gases				
Brunswick Mining and Smelting	Belledune, N.B.	SO_2 lead-zinc	125,000	42,000
Allied Chemical	Valleyfield, Que.	SO_2 zinc conc.	140,000	47,000
Canadian Electrolytic Zinc	Valleyfield, Que.	SO_2 zinc conc.	120,000	40,000
Canadian Industries[1]	Copper Cliff, Ont.	SO_2 pyrrhotite	900,000	300,000
Cominco[1]	Trail, B.C.	SO_2 lead-zinc	435,000	145,000
	Kimberley, B.C.	SO_2 pyrrhotite	275,000	92,000
Texasgulf Canada Ltd.	Timmins, Ont.	SO_2 zinc conc.	205,000	70,000
Gaspé Copper Mines	Murdochville, Que.	SO_2 copper	245,000	82,000
		TOTAL	2,435,000	895,000
Pyrite and pyrrhotite				
Noranda Mines	Noranda, Que.	Sulphide ore	Pyrite concentrate[2]	
Normetal Mines Limited	Normetal, Que.	Sulphide ore	Pyrite concentrate[2]	

[1]Does not include 85,000 tons sulphur content in liquid SO_2 production. [2] Currently inactive.

Table 5. Canada, sulphur production and trade, 1966-75

	Production				Imports	Exports	
	Pyrites[1]	In Smelter Gases	Elemental Sulphur	Total	Elemental Sulphur	Pyrites	Elemental Sulphur
	(long tons)					($)[2]	
1966	144,901	446,702	1,822,676	2,414,279	129,871	981,000	1,249,113
1967	162,826	528,568	2,231,290	2,922,685	111,404	1,067,000	1,583,533
1968	139,136	594,935	2,304,090	3,038,161	67,688	1,056,000	1,884,821
1969	152,858	603,702	2,654,746	3,411,306	40,630	1,105,000	2,005,480
1970	156,707	630,206	3,167,931	3,954,844	47,725	1,226,000	2,668,072
1971	138,421	552,185	2,811,677	3,502,283	27,484	1,074,000	2,364,190
1972	61,204	606,110	3,246,099	3,913,413	25,091	501,000	2,542,896
1973	11,466	675,496	4,101,656	4,788,618	35,194	659,000	3,437,303
1974	24,089	652,845	4,953,568	5,630,502	30,893	648,000	4,184,306
1975[p]	9,375	695,536	3,999,107	4,704,018	14,109	170,000	3,244,340

Source: Statistics Canada.
[1]See footnote for Table 1. [2]Dollar value of pyrite exports, quantities not available.
[p]Preliminary.

purchases, were little changed in 1975 at 920,000 tons. Asian sales declined 26 per cent to 550,000 tons, essentially as a result of a halving of Taiwan's 400,000-ton purchase in 1974. Australasia registered the greatest decline, almost 50 per cent from the previous year's 685,000 tons. Sales to Latin America were down 7 per cent and those to Africa were down 44 per cent.

World review

World sulphur production in 1975 declined marginally from the previous year as a result of reduced output from both voluntary and involuntary byproduct operations. The cutbacks were, in part, in response to reduced demand, but more permanent constraints to production, which have developed amongst several major world suppliers over the past few years, have begun to take effect. The effects of exhaustion of reserves, limited exploration success and prohibitive energy costs in established producing areas have been further magnified by slower-than-anticipated developments in new source areas.

Slack demand during the year affected virtually all manufacturing sectors and buyer resistance to phosphate fertilizer prices, driven up by a 500 per cent increase in phosphate rock prices, further depressed sulphur markets. Except for Poland, whose exports were virtually unchanged from the previous year, all major elemental sulphur exporters experienced a decline in sales. Pyrite exports continued a decline which began in 1969 as a result of increasing competition with elemental sulphur output.

World consumption in 1975 was an estimated 46.0 million tons, with 5.4 million tons being added to world stockpiles.

The world's largest producer of sulphur in all forms is the United States, with the majority of production derived from Frasch-method mines located in the Gulf Coast area. Development of the Frasch mining technique in 1895 made large tonnages of low-cost sulphur available to world markets and established the United States as the world's foremost supplier of elemental sulphur. In 1975 Frasch production fell from the record high of 7.90 million tons in 1974 to 7.21 million tons and recovered elemental sulphur, principally from sour natural gas, increased 13 per cent to 2.97 million tons. Shipments of elemental sulphur dropped 14 per cent from 1974 and stocks jumped 30 per cent to 5.13 million tons. Exports in 1975 at 1.29 million tons were half those of the previous year, imports decreased 12 per cent to 1.9 million tons and domestic consumption of elemental sulphur was down 4 per cent to 9.5 million tons. Freeport Minerals Company's Lake Pelto mine was closed during the year and Texasgulf Inc's Spindletop mine closed in early 1976.

Mexican elemental sulphur production decreased 7.5 per cent in 1975 to 2.12 million tons. Domestic shipments, which have tripled in six years in response to growth in the fertilizer industry, reached an estimated 750,000 tons in 1975. As a result of depressed markets and reported technical problems in production, Mexico's exports declined 25 per cent to 1.4 million tons.

Production of elemental sulphur from sour natural gas from the Lacq field in France in 1975 was 1.8 million tons, a production plateau reached in 1969. Exports decreased by 40 per cent to 0.56 million tons in 1975. Elemental sulphur output from sour gas in northern West Germany decreased 7 per cent to 0.51 million tons. This source, although generally having increased its capacity utilization over the years, has been plagued by technical problems.

Table 6. Canadian export markets, 1975

Country or Area	Exports	Per cent of Total
	(millions of long tons)	
United States	.96	29.63
Europe	.92	28.40
Australia	.25	7.72
South Africa	.18	5.55
Taiwan	.19	5.86
India	.12	3.70
South Korea	.11	3.40
New Zealand	.10	3.09
Others	.41	12.65
Total	3.24	100.00

Source: Mineral Development Sector, Department of Energy, Mines and Resources, Ottawa.

Table 7. Canada sulphur consumption, 1966-75

	From Pyrites and Smelter Gases^{e}	Elemental Sulphur[1]	Total^{e}
	(long tons)		
1966	461,478	725,053	1,186,531
1967	590,185	752,963	1,343,148
1968	669,763	741,155	1,410,918
1969	680,438	688,211	1,368,649
1970	682,992	751,543	1,434,535
1971	562,645	718,443	1,281,088
1972	600,093	846,955	1,447,048
1973	643,290	892,594	1,535,884
1974	631,965	882,985	1,514,950
1975^{p}	687,203	. .	. .

Source: Statistics Canada.
[1] As reported by consumers.
^{e} Estimated by Mineral Development Sector, Department of Energy, Mines and Resources, Ottawa. ^{p} Preliminary.

Polish production increased 9 per cent over that of 1974 to 4.31 million tons, reflecting the sharp increase in output achieved through solutions to technical problems at the Machow open-pit and improved performance in two Frasch operations during the latter part of 1974. Exports to western markets fell 23 per cent to 1.52 million tons; however, this loss was balanced by a 0.51-million-ton increase in sales to eastern bloc countries. New mine developments now in hand could increase supply capabilities substantially over the next few years.

Iraq became a significant producer of elemental sulphur in 1973. Capacity is reported to have reached 1 million tons a year but no expansion to the estimated 700,000-ton output is expected until rail transport capability to the Persian Gulf port of Umm Qasr, 450 miles to the south, is improved. Shipments by truck to Lebanon for Mediterranena customers were begun in 1974 and a large fleet of trucks is on order with Mercedes in Germany.

Outlook

The near-term outlook for sulphur, at least on the demand side of the equation, is made uncertain by the current world-wide economic slowdown. As for supply, a slowdown in base-metal production correspondingly reduces smelter acid supply. However, increases in supply from other sources are limited by factors unrelated to the recession. Availability of elemental sulphur from Canada and Iraq is constrained by transportation bottlenecks, although use of alternate ports in Canada offers modest relief. United States Frasch-method producers are facing rapidly escalating costs and a dwindling reserve picture, Mexican producers are experiencing technical problems and France's elemental sulphur output reached a plateau several years ago. Of the major producers, only Poland appears to be capable of increasing output significantly in 1976. Demand for fertilizers fell sharply in 1975 and with large inventories of finished fertilizers held by producers and distributors, recovery will be slow. During 1976 sulphur supplies will be more than adequate, even with a reduction in output.

For the longer-term, fertilizer requirements, under the stimulus of world food shortages and the expansion of modern agricultural practice in Asia, Africa and Latin America, will continue to consume a growing proportion of sulphur output. Many observers interpret growing substitution by hydrochloric and other acids in the important pigment, steel pickling and oil refining sectors as presaging a significant tapering off of growth in sulphur consumption in the manufacturing sector, and thus an overall moderation of sulphur consumption growth. However, an examination of the positive as well as the negative elements in the demand picture suggests that such a view may be too pessimistic. In fact, when considering substitution, sulphur's role in the manufacture of substitute reagents must be taken into account. For example, the expected switch to hydrofluoric acid in petroleum refining could result in an increase in sulphur consumption, since three tons of H_2SO_4 is needed to produce one ton of HF. Also in addition to conventional fertilizer use, attention has been drawn in recent years to sulphur's important role as a plant nutrient and to sulphur deficiencies in the soil over broad areas throughout the world. An area of growth in the "other uses" category is that of uranium production. Uranium ore leaching requires 30 to 50 tons of sulphuric acid per ton of uranium in the ore,

Table 8. Canada, consumption of elemental sulphur by industry

	1973	1974
	(long tons)	
Chemicals	85,634[r]	86,923
Pulp and Paper	300,088	294,334
Rubber Products	2,730[r]	3,016
Fertilizers	438,573[r]	442,379
Foundry	5,681[r]	11,075
Other Industries[1]	59,888[r]	45,258
Total	892,594	882,985

Source: Statistics Canada. Breakdown by Mineral Development Sector, Department of Energy, Mines and Resources, Ottawa.
[1]Includes production of titanium pigments, pharmaceuticals and medicinals, starch, soaps and detergents, explosives, food processing, sugar refining and other minor uses.
[r] Revised.

plus additional acid indirectly in the manufacture of hydrofluoric acid and other chemicals used in processing. Demand for sulphur contained in acid for world uranium production in 1975 was an estimated 350,000 tons. By the year 2000, annual requirements are expected to exceed 2 million tons. Ore and tailings leaching in base-metal production and anticipated developments in hydrometallurgy are other consuming areas with high growth potential. Several new uses for elemental sulphur based on attractive engineering properties have been under development in recent years. Although some of these are fairly sensitive to sulphur prices, uses such as sulphur-asphalt road surfacing mixtures could become important consumers of sulphur. In summary, it would appear that the historical sulphur demand growth of 4.5 per cent a year will be maintained over the medium to long term and, with fertilizer developments, could exceed the historical rate.

In the final analysis, sulphur supply is likely to be the most important factor in sulphur's fortunes. As one of the earth's most abundant elements, no ultimate shortage is foreseeable; however, an examination of likely rates of development from the various sources provides a less-assuring outlook.

Although Canada is the world's largest exporter of sulphur with a 30-per-cent share of total trade, its impact on world sulphur markets is expected to decline. Production of elemental sulphur from sour natural gas peaked in 1973 at 7.1 million tons and output in 1975 was 8.5 per cent less than this figure. Several of the major plants are recycling operations, i.e., sulphur is stripped from the gas and the gas returned to the reservoir. Output from these plants is now tapering off, and considering the reserve picture for the others, a reduction to about one-half of the current output from existing plants is expected by 1985. Replacement of

Table 9. Canada, sulphuric acid production, trade and apparent consumption, 1966-75

	Production	Imports	Exports	Apparent Consumption
	(short tons — 100% acid)			
1966	2,500,000	6,948	54,948	2,452,000
1967	2,749,279	3,626	84,280	2,668,625
1968	2,852,027	2,606	125,971	2,728,662
1969	2,396,535	60,746	103,386	2,353,895
1970	2,728,298	10,966	142,559	2,596,705
1971	2,933,000	4,952	101,094	2,836,858
1972	3,030,182	70,112	104,227	2,996,067
1973	3,265,772	72,451	135,210	3,203,013
1974	3,109,605[r]	137,502	274,693	2,972,414[r]
1975[p]	3,001,816	169,778	166,771	3,004,823

Source: Statistics Canada.
[r] Revised: [p]Preliminary.

Table 10. Canada, available data on consumption of sulphuric acid by industry, 1973

	(short tons — 100% acid)
Iron and steel mills	26,188
Other iron and steel	13,991
Electrical products	5,085
Pulp and paper mills	164,368
Processing of uranium ore	82,323
Manufacture of mixed fertilizers[1]	18,346
Manufacture of plastics and synthetic resins	18,165
Manufacture of soaps and cleaning compounds	21,919
Other chemical industries	62,471
Manufacture of industrial chemicals[2]	2,124,698
Petroleum refining	33,944
Mining[3]	50,000[e]
Nonferrous smelting and refining	153,739
Miscellaneous[4]	13,369
Total	2,788,606

Source: Statistics Canada.
[1]Includes consumption for production of super-phosphate in this country. [2]Includes consumption of "own make" or captive acid by firms, classified to these industries. [3]Includes metal mines, nonmetal mines, mineral fuels and structural materials. [4]Includes leather tanneries, synthetic textiles, explosives and ammunition and other petroleum and coal products, mineral wool, starch and glucose, vegetable oils, sugar refining and textile drying and finishing.
[e] Estimated.

part of this lost production capability through new discoveries and reserve extensions, especially with the recent gas price increases, will occur. However, given the fact that only one significant sour gas find — Shell's Rosevear discovery in 1975 — has been made during the last six or seven years, and considering a lag time of three or four years between discovery and production, no major increment in output is likely before the end of the decade. Sulphur recovery from the Athasbasca oil sands depends on the rate of exploitation of this source of oil. Current estimates in the order of 400,000 barrels a day by 1985 are less by two-thirds than earlier projections. Sulphur from metallic sulphides, produced largely in the form of sulphuric acid, could double by 1985. However, it is unlikely that new sour gas discoveries and growth in output of metallurgical and oil sands sulphur will be adequate to offset the decline in Canadian production before the late 1980s.

United States Frasch sulphur output declined 9 per cent in 1975 from the previous year. Although much of this reduction was in response to weak demand, two critical constraints are making themselves felt. Costs have more than doubled recently as a result of price increases for essential natural gas. At best, producers will have to face continued escalating production costs, and fuel supply cuts remain a distinct possibility. Also, notwithstanding the success of the Duval Corporation's mine in west Texas, which has a capacity of 2.4 million tons a year, and Texasgulf Inc.'s 500,000-ton-a-year operation scheduled for 1976, there is little scope for growth in Frasch output. The closure of Freeport Minerals Company's Lake Pelto mine during 1975 and Texasgulf's Spindletop mine in early 1976 is symptomatic of a net decline in reserves. Of 37 Frasch mines developed since the inception of the industry in 1895, only 11 remain in operation. More significantly, of 12 mines developed during the last 15 years, seven have closed. Exploration and development to date indicates that the decline is unlikely to be arrested and probable output by 1985 is forecast by various analysts at between 5.5 and 6.5 million tons.

Although there is scope for sulphur exploration and development in Mexico, present Frasch operations are experiencing technical difficulties in addition to cost constraints similar to those met in the United States. Except for the all-time high of 2.3 million tons in 1974, production has varied between 1.2 and 1.8 million tons during its lengthy history. Without exploration successes, significant production growth is highly unlikely.

Sulphur production from sour natural gas in France is expected to decline to 1.5 million tons by 1985.

Poland's Frasch production may reach 6 million tons, and the newly emerging Middle East producers — sour gas and Iraqi Frasch — will likely rise to 3.0 million tons by 1985.

Despite the fact that pollution abatement sulphur will become more important, its impact is proving to be less dramatic than earlier predictions suggested for the following reasons. For sulphur removal from electric utility stack gases, the largest source of pollution-sulphur, economic and technologic considerations weigh in favour of a scrubbing process which will result in an inert discardable waste product; a number of smelters are located in areas lacking adequate markets for sulphuric acid which will likely result in a similar disposal of surplus acid; and in light of energy supply considerations, attention has been focussed on conservation, which may moderate growth in fossil fuel consumption, the major source of sulphur emissions.

Table 11. World production of sulphur in all forms, 1974

	Elemental	Other[1]	Total
	(thousands of metric tons)		
United States	10,702	1,450	12,152
U.S.S.R.	2,500	6,039	8,539
Canada	7,093	748	7,841
Poland	4,030	280	4,310
Japan	725	2,083	2,808
Mexico	2,323	50	2,373
France	1,929	142	2,071
West Germany	558	801	1,359
Spain	6	1,271	1,277
Italy	68	702	770
Iran	605	—	605
Finland	100	400	500
East Germany	112	257	369
Norway	4	326	330
South Africa	28	299	327
Australia	8	295	303
Others	1,820	4,033	5,853
Total	32,611	19,176	51,787

Source: British Sulphur Corporation, November-December 1975.
[1]Sulphur in other forms includes sulphur contained in pyrites, and contained sulphur recovered from metallurgical waste gases, mostly in the form of sulphuric acid.
— Nil.

Under the influence of these factors, and coupled with demand pressures for fertilizers, sulphur inventories should peak in the next few years and supply and consumption will tend toward a balance, perhaps reaching that point in the early 1980s.

Prices

A firming trend, which characterized prices over the last three years, was interrupted by the present recession. A resistance to price erosion despite sharply reduced sales was evident and, in fact, prices in the United States were raised from \$45-\$55 fob Gulf port in 1974 to \$60-\$73 in 1975. This development is probably a reflection of the Frasch production costs which have more than doubled in recent years. A recovery in the world economies should result in increased prices, although there would likely be a lag of several months while customer inventories were being reduced.

Canadian sulphur prices quoted in Canadian Chemical Processing, November 1975.

	($)
Sulphur, elemental, fob works contract, carload, per long ton	27.50
Sulphuric acid, fob plants, east 66° Be, tanks, per short ton December	65.00

United States prices in U.S. currency, quoted in Engineering and Mining Journal, December 1975.

	($)
Sulphur elemental	
U.S. producers, term contracts fob vessel at Gulf ports, La. and Tex., per long ton (nominal)	
Bright	61.00-63.50
Dark	60.00-62.50
Export prices, fob Gulf ports	
Bright	65-73
Dark	64-72
Mexican export fob vessel per long ton	
Bright	61
Dark	60

Tariffs

Canada

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
92503-1	Sulphur of all kinds, other than sublimed sulphur, precipitated sulphur and colloidal sulphur	free	free	free	free
92802-1	Sulphur, sublimed or precipitated, colloidal sulphur	free	free	free	free
92807-1	Sulphur dioxide	free	free	free	free
92808-1	Sulphuric acid, oleum	10%	15%	25%	10%
92813-4	Sulphur trioxide	free	free	free	free

United States

Item No.		
418.90	Pyrites	free
415.45	Sulphur, elemental	free
416.35	Sulphuric acid	free

Item No.		(%)
422.94	Sulphur dioxide	
	On and after Jan. 1, 1970	8.5
	On and after Jan. 1, 1971	7
	On and after Jan. 1, 1972	6

Sources: The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa. Tariff Schedules of the United States, Annotated (1976), T.C. Publication 749.

Talc, Soapstone and Pyrophyllite

G.H.K. PEARSE

Talc is a hydrous magnesium silicate $H_2Mg_3(SiO_3)_4$ formed by the alteration of rocks rich in magnesia (most commonly ultrabasic igneous rocks and sedimentary dolomite) within which it occurs as veinlets, tabular bodies, or irregular lenses. It is a soft flaky mineral with a greasy feel or "slip", it is readily ground to a fine white or nearly white powder, has a high fusion point, low thermal and electrical conductivity and is relatively chemically inert. Most of the uses of talc depend on individual physical properties or combinations of these properties.

Talc is produced in various grades which are usually classified by end use; cosmetic, ceramic, pharmaceutical and paint. A special high-quality block talc used in making ceramic insulators and other worked shapes is designated steatite grade.

Soapstone is an impure talcose rock generally occurring in massive, compact deposits from which blocks can be sawn. Soapstone has been used since early times in many parts of the world for carving ornaments, pipes, cookware, lamps and other utensils. The art of carving this rock has survived among the Eskimos up to the present era. Present uses include metalworkers' crayons, refractory bricks, and blocks for sculpturing.

Pyrophyllite is a hydrous aluminum silicate $H_2Al_2(SiO_3)_4$ formed by hydrothermal alteration of acid igneous rocks, predominantly lavas which are andesitic to rhyolitic in composition. It resembles talc in physical properties and for this reason finds uses similar to talc, notably in ceramic bodies and as a filler in paints, rubber and other commodities.

In Canada, talc is produced in two provinces, Quebec and Ontario. Pyrophyllite is produced only in Newfoundland. The value of talc and soapstone shipments decreased from $1,405,303 in 1974 to $1,263,000 in 1975. The value of pyrophyllite production decreased from $507,552 in 1974 to $420,000 in 1975. The decrease in value of these shipments is attributable to reduced tonnages demanded as a result of the recession which developed in late 1974.

Production and developments in Canada

Talc, soapstone. The earliest recorded production in Canada was in 1871-72 when 300 tons of cut soapstone valued at $1,800 were shipped from a deposit in L 24, R 6 in Bolton Township, southern Quebec, by Slack and Whitney. In 1896 a deposit in Huntingdon Township, in the Madoc district in Ontario, was opened and over the next few years numerous deposits were discovered in this area and mined intermittently.

Several deposits in southern British Columbia and one in southwestern Alberta were discovered prior to 1920 and some of these were worked in a small way. At present, talc is mined by four companies — two in Quebec and two in Ontario.

Baker Talc Limited produces talc and soapstone from an underground mine in South Bolton, Quebec, 60 miles southeast of Montreal. Ore from the mine is trucked 10 miles south to the company's mill facilities at Highwater. In former years, Baker Talc produced a relatively low-grade, low-cost product suitable for use primarily as a dry-wall joint filler, asphalt filler and dusting compounds for asphalt roofing. Tests conducted in 1967-68, employing a Jones High Intensity Wet Magnetic Separator, demonstrated that the company's talc could be upgraded for use in the paint, cosmetic and paper industries and this process was added to the mill circuit in 1969. This project was supported by the federal Department of Industry, Trade and Commerce. Subsequently, a modified flotation process replaced the magnetic separator, which resulted in improved output.

Current output of high-grade product, destined largely for paper mills, is around 5,000 tons a year. Expansions, begun in 1973, were completed during 1974; however, the economic downturn caused sales to decline during the latter half of the year and throughout 1975. Minor shipments have also been made for use as a filler in plastics and paints and, from time to time, the company markets soapstone blocks as an artistic medium to schools and shops.

Table 1. Talc, soapstone and pyrophyllite production, trade and consumption, 1974-75

	1974		1975[p]	
	(short tons)	($)	(short tons)	($)
Production (shipments)				
Talc and soapstone				
Ontario[1]	. .	723,119	. .	635,000
Quebec[2]	. .	682,184	. .	628,000
Total	. .	1,405,303	. .	1,263,000
Pyrophyllite				
Newfoundland	. .	507,552	. .	420,000
Total Production	94,746	1,912,855	74,000	1,683,000
Imports (Talc)				
United States	39,625	2,507,000	33,331	2,296,000
Italy	281	41,000	76	15,000
Other countries	51	4,000	130	13,000
Total	39,957	2,552,000	33,537	2,324,000
		1973[r]		1974[p]
Consumption[3] (ground talc available data)				
Ceramic products		7,232		8,066
Paints and wall joints sealers		9,839		10,344
Roofing		9,373		7,505
Paper and paper products		5,247		7,067
Rubber		1,946		1,312
Insecticides		316		558
Toilet preparations		842		868
Cleaning compounds		290		223
Pharmaceutical preparations		1,917		1,930
Linoleum and tile		162		279
Other products[4]		5,123		7,182
Total		42,287		45,334

Source: Statistics Canada.
[1]Ground talc. [2]Ground talc, soapstone, blocks and crayons. [3]Breakdown by Mineral Development Sector, Department of Energy, Mines and Resources, Ottawa. [4]Chemicals, foundries, gypsum products and other miscellaneous uses.
[p]Preliminary; . . Not available; [r]Revised.

Broughton Soapstone & Quarry Company, Limited, quarries talc and soapstone from two deposits near Broughton Station in the Eastern Townships of Quebec, where the same geological conditions are evident as in the South Bolton area. Several low-priced grades of ground talc are produced, and soapstone is sawn to produce metalworkers' crayons and various sizes of blocks for sculpturing and plates for etching. Much of the Eskimo artists' soapstone requirements are supplied by this company.

Canada Talc Industries Limited produces talc from underground workings at Madoc, Ontario. The deposits at Madoc are extensive and were formed by the alteration of dolomitic marble. Tremolite and dolomite impurities in the deposit limit the use of some ground products. A high-quality product suitable as a filler material in the paint industry is produced.

Canadian Johns-Manville Company, Limited brought their Penhorwood township deposit into production in July 1976. It will produce paper-grade talc as its first product. The plant is 45 miles southwest of Timmins.

Numerous deposits of talc and soapstone occur in other parts of Canada. A soapstone deposit on Pipestone Lake in Saskatchewan was worked by Indians for the manufacture of pipes and various utensils. Reserves are reported to be considerable. High quality "blue" talc was investigated in the Banff area of

Alberta and British Columbia during the 1930s. In the Northwest Territories, a few occurrences of soapstone are known from which Eskimos obtained material for carving. Showings of minor importance occur at several localities in Nova Scotia and Newfoundland.

Pyrophyllite. Newfoundland Minerals Limited, a subsidiary of American Olean Tile Company, Inc. produces pyrophyllite from an open-pit mine near Manuels, 12 miles southwest of St. John's, Newfoundland. Ore is crushed, sized and hand-cobbed at the mine site prior to being trucked a short distance to tidewater. Continuous chemical analyses and physical tests are run on all material delivered from the mine to the loading dock. Blended ore is shipped in bulk to the parent company's operation at Lansdale, Pennsylvania, where it is used in the manufacture of ceramic tile. Annual production varies between 30,000 and 40,000 tons. The pyrophyllite deposit at Manuels appears to be a hydrothermal alteration of sheared rhyolite. Altered zones are associated for the most part with extensive fracturing near intrusive granite contacts. Reserves are extensive.

Table 2. Production and trade, 1966-1975

	Production[1]			
	Talc and Soapstone	Pyrophyllite[2]	Total[3]	Imports Talc
	(short tons)			
1966	29,596	40,548	70,144	24,918
1967	. .	. .	60,665	26,487
1968	. .	. .	80,589	28,244
1969	. .	. .	75,850	34,910
1970	. .	. .	72,055	33,068
1971	. .	. .	65,562	33,752
1972	. .	. .	80,946	40,505
1973	. .	. .	81,495	33,033
1974	. .	. .	94,746	39,957
1975^p	. .	. .	74,000	33,537

Source: Statistics Canada.
[1]Producers' shipments; [2]Producers' shipments of pyrophyllite, all exported; [3]From 1967, breakdown of producers' shipments not available for publication.
^{p}Preliminary; . . Not available.

Other known pyrophyllite deposits in Canada include an extensive area of impure pyrophyllite near Stroud's Pond in the southern part of Burin Peninsula, Newfoundland; a deposit near Ashcroft, British Columbia; and three deposits on Vancouver Island, British Columbia, in the Kyuquot Sound area, 200 miles northwest of Victoria. The Vancouver Island deposits were worked on a limited scale in the early part of this century.

Trade and markets

Most talc and soapstone produced in Canada is consumed domestically, while all pyrophyllite produced is exported. Imported talc, most of it from the United States, is high-quality, high-value material suitable for use in the paint, ceramics, paper and cosmetic industries. Production of these superior grades of talc in Canada began in 1970 with the new beneficiation techniques incorporated into Baker Talc's mill and, in 1971, a product acceptable to the pulp and paper industry was marketed. Johns-Manville's new deposit is reportedly of this quality. It is anticipated that imported high-quality talc will soon be displaced to some extent in other industries by this domestic product. Imports, nearly all from the United States, in 1975 amounted to 33,537 tons valued at $2,324,000, down 16 per cent in tonnage and 9 per cent in value from 1974. This reduction reflects soft markets rather than displacement by domestic production. Average value of imports in 1975 was $70 a ton, while domestic production sells in the range of $10-75 a ton, depending upon quality.

Table 3. World production of talc, soapstone, and pyrophyllite, 1973-1975

	1973	1974^p	1975^e
	(short tons)		
Japan	1,723,540	1,734,878	1,700,000
United States	1,246,533	1,151,914	1,100,000
South Korea	460,693	496,039	. .
U.S.S.R.	440,924	451,947	. .
France	284,188	334,996	270,000
India	228,344	231,485	. .
Italy	161,539	171,960	150,000
People's Republic of China	165,347	165,347	. .
Norway	150,396	154,323	. .
Finland	120,928	141,392	130,000
North Korea	121,254	132,277	. .
Austria	101,638	108,511	. .
Brazil	99,208	99,208	. .
Canada	81,495	94,746	74,000
Australia	71,439	80,469	. .
Romania	66,139	66,139	. .
Other countries	287,321	300,650	. .
Total	5,810,926	5,916,281	5,450,000

Sources: U.S. Bureau of Mines, Mineral Trade Notes, Vol. 72, No. 9, September 1975, U.S. Bureau of Mines. Commodity Data Summaries, January 1976; Statistics Canada.
^{p}Preliminary; ^{e}Estimated; . . Not available.

Uses

Talc is used mostly in a fine-ground state; soapstone in massive or block form. There are many industrial applications for ground talc, but major consumption is limited to less than a dozen industries.

Talc is used as a filler material in the manufacture of high-quality paper where it aids in dehydration of the pulp, improves sizing characteristics, reduces the tendency of papers to yellow and assures a well-bonded surface to promote ease of printing. For use in the paper industry, talc must be free of chemically active compounds such as carbonates, iron minerals and manganese; have a high reflectance, possess high retention characteristics in the pulp, and be free of abrasive impurities. Micronized material provides a high-gloss finish on coated papers.

The ceramic industry utilizes very finely ground talc to increase the translucence and toughness of the finished product and aid in promoting crack-free glazing. For use in ceramics, talc must be low in iron, manganese and other impurities which would discolour the fired product.

High-quality talc is used as an extender pigment in paints. Specifications for a talc pigment, as established in ASTM Designation D605-69, relate to the chemical composition, colour, particle size, oil absorption and consistency of, and dispersion in, a talc-vehicle system. A low content of carbonates, a nearly white colour, a fine particle size with controlled particle size distribution and a specific oil absorption are important. However, because of the variety of paints, precise specifications for talc pigments are generally based on agreement between consumer and supplier. Paint characteristics influenced by the use of talc as an extender are gloss, adhesion, flow, hardness and hiding power.

Talc is well known for its use in pharmaceutical preparations and cosmetics. It is the major ingredient in face, baby and body powders. Finely ground, high-purity material is used as a filler in tablets and as an additive in medical pastes, creams and soaps. Material used for these purposes should be free of deleterious chemical compounds, abrasive impurities and fibrous minerals such as tremolite and asbestos, which are believed to be injurious to health when inhaled or ingested.

Lower-grade talc is used as a dusting agent for asphalt roofing and gypsum board, as a filler in drywall sealing compounds, as a filler material in floor tiles, in asphalt pipeline enamels, in auto-body patching compounds, as a carrier for insecticides, as a filler or dusting compound in the manufacture of rubber products.

Other applications for talc include use in cleaning compounds, polishes, electrical cable coating, plastic products, foundry facings, adhesives, linoleum, textiles and in the food industry.

Particle-size specifications for most uses require the talc to be minus 325 mesh. The paint industry demands from 99.8 to 100 per cent minus 325 mesh. For rubber, ceramics, insecticides and pipeline enamels, 95 per cent minus 325 mesh is usual. In the wall-tile industry 90 per cent minus 325 mesh is generally required. For roofing grades the specification is about minus 80 mesh, with a maximum of 30 to 40 per cent minus 200 mesh.

Soapstone has now only very limited use as a refractory brick or block but, because of its softness and resistance to heat, it is still used by metalworkers as marking crayons. The ease with which it can be carved makes it an excellent artistic medium.

Pyrophyllite can be ground and used in much the same way as talc, but at present the use of the Canadian material is confined to ceramic tile. It must be minus 325 mesh and contain a minimum of quartz and sericite, which are common impurities.

World review

Deposits of talc are widely distributed throughout the world, but have been commercially developed only in the more industrialized countries. Because talc is of relatively low unit value, only a very small proportion of world production is traded internationally. The majority of international trade takes place within Europe, in the Far East between Japan, the People's Republic of China and Korea, and in North America between Canada and the United States. However, talc of exceptional purity is valuable enough to withstand the cost of transportation over much greater distances. For example, high-grade French, Italian, Indian and Chinese talcs are shipped throughout the world.

Prices

United States talc prices according to Oil, Paint and Drug Reporter, December 31, 1975.

	($ per ton)
Canadian	
Ground, bags, carlot, fob mines	20.00-35.00
Vermont	
Domestic, ordinary, offcolour, ground, bags, carlot, fob works	22.25
California	
Domestic, ordinary offcolour, bags, carlot fob works	34.00-39.50
New York	
Domestic fibrous ground bags	35.50

Tariffs

Canada

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
		(%)	(%)	(%)	(%)
71100-3	Talc or soapstone	10	15		10
71100-8	Micronized talc	free	5		free
29655-1	Pyrophyllite	free	free	25	free
29645-1	Talc for use in manufacturing of ceramic tile (expires Feb. 28, 1977)	free	free	25	free
29646-1	Talc for use in manufacture of pottery (expires Feb. 28, 1980)	free	free	25	free

United States

Talc, steatite, soapstone

Item No.		
523.31	Crude and not ground	0.02¢ per lb.
523.33	Ground, washed, powdered, or pulverized	6%
523.35	Cut or sawed, or in blanks, crayons, cubes, disks, or other forms	0.20¢ per lb.
523.37	All other, not provided for	12%

Sources: For Canada, The Customs Tariff and Amendments, Department of National Revenue, Customs Excise Division, Ottawa. For United States, Tariff Schedules of the United States, Annotated (1976), TC Publication 749.

Tin

G.S. BARRY

Tin is one of the few metals that Canada imports in large quantities. Domestic production is small and exported in the form of concentrates to the United States, the United Kingdom and Mexico. Mine production is not sufficient to support a domestic smelter.

Canadian production in 1975 of tin-in-concentrates and lead-tin alloy was 283 tonnes*, valued at $2,192,-000.

Canadian industrial requirements of tin are met mainly by imports that totalled 4,491 tonnes in 1975, valued at $33,076,000.

Canada also imports small quantities of tinplate (less than 1 per cent of domestic production), mainly from the United States. Tin metal scrap and tinplate scrap is mainly exported to the United States, as facilities for secondary metal processing in Canada are very limited. Tin-bearing secondary solders are recovered in a few plants, for example, Federated Genco Limited at its Scarborough plant, Toronto. These are mainly melted away from products such as car radiators and pipes, and are reconstituted as solders. Statistics on the amounts recovered, however, are not available.

M&T Products of Canada Limited, Hamilton, Ontario recovers a secondary tin product by detinning industrial and municipal scrap. The product is potassium stannate, used mainly in electroplating. Thus, an equivalent of 120 to 140 tonnes of tin is recovered annually.

Traditionally, Malaysia was the main supplier of Canadian requirements of tin (e.g. 64 per cent in 1973) but this pattern changed in 1974, with the United States becoming the main supplier of Canadian imports, principally as a result of major releases of tin from the GSA stockpile. In 1975, Malaysia once again became the main supplier, closely followed by the United States and Australia. Imports from Brazil, which began in 1973, continued at the same level. Total imports declined by 19 per cent, clearly indicating the low level of economic activity and also reflecting the substantial buildup of consumer inventories in 1974 that had to be carried through 1975.

Until the end of 1973, Cominco Ltd. was the only mine producer of tin, recovering cassiterite (SnO_2) as a byproduct from milling lead-zinc ores at Kimberley, British Columbia. The company's annual output is between 100 and 150 tonnes, and prospects for any increases are nil. Mining is moving away from moderately tin-bearing, base-metal sulphides, and production from 1975 onward may be below the historical average.

Besides the tin concentrate recovered at Kimberley, Cominco recovers about 600 tonnes annually of a lead-tin alloy from treatment of lead bullion dross in the indium circuit of its Trail smelter. The tin content of this alloy is about 8 per cent. The company also produces, from purchased commercial-grade metal, small quantities of Tadanac brand high-purity tin (99.9999 per cent) and special research grade (99.999 per cent) tin. Texasgulf Canada Ltd., formerly Ecstall Mining Limited, a subsidiary of Texasgulf Inc., completed construction of a tin-circuit at its base metal concentrator at Timmins in the spring of 1974. This installation was designed to recover approximately 1,600,000 pounds of tin annually, but recoveries during 1974 and 1975 were below expectation and production targets were not reached. During the year the company initially directed efforts mainly in achieving grade levels of about 54 per cent tin in the concentrates. Subsequently, the company also experimented in the production of much lower-grade concentrates, thus improving overall tin recovery. It is expected that the company will be able to focus on the most satisfactory technique during 1976.

Fine-grained cassiterite is a mineralogical component of sulphide ores of several Canadian mines but cannot be recovered economically, except at the Sullivan mine of Cominco and the Kidd Creek mine of Texasgulf mentioned above. Ore grades at these mines are between 0.15 and 0.25 per cent SnO_2. Tin is present in small quantities in the zinc-lead orebodies of Brunswick Mining and Smelting Corporation Limited, New Brunswick and in the South Bay, Ontario mine of Selco Mining Corporation Limited.

Brunswick Tin Mines Limited, a subsidiary of the Sullivan Mining Group Ltd., continued exploration and metallurgical testing on its multimineral deposit in southwestern New Brunswick. Reserves for the Fire

*The tonne (metric ton) of 2,205 pounds is used throughout.

Tower Zone reported in 1973 are 29.5 million tonnes, with an average grade of 0.20 per cent tungsten, 0.09 per cent molybdenum, 0.08 per cent bismuth, 0.04 per cent tin, 0.07 per cent copper, 0.35 per cent zinc, 0.08 per cent lead, 4 per cent fluorspar and about one ounce of indium per ton. In addition, diamond drilling completed in 1973 on the North Zone, a little more than half a mile north of the Fire Tower deposit, indicated over 1,000,000 tonnes grading approximately 0.5 per cent tin, with higher grade in deeper holes. Additional work on the property, and metallurgical testing during 1974 and 1975, allowed the company to remain optimistic about mining prospects of this property. A decision on production is likely to be made during 1976. However, it is quite likely that if a production decision is reached, initial mining will mainly concentrate on the bismuth-molybdenum and tungsten-rich zones, and tin may not even be a byproduct during the early stage of operations.

The principal use of tin in Canada, accounting for over 50 per cent of the total consumption, is in the production of tinplate. There are two producers; Dominion Foundries and Steel, Limited (Dofasco) and The Steel Company of Canada, Limited (Stelco) both at Hamilton, Ontario. Canadian output of tinplate is all electrolytic; hot-dip production ceased in 1966. It is estimated that in 1974 approximately 2,975 tonnes of tin were used to produce 585,300 tonnes of tinplate and in 1975, 2,286 tonnes to produce 449,100 tonnes of tinplate.

Dofasco and Stelco each operate three electrolytic tinplate lines. Stelco's third line, with a capacity of 175,000 tonnes of tinplate a year, was commissioned in November 1971. It can be converted to produce steel with other types of coatings, notably chrome-coated steel. Dofasco's third line is also dual-purpose, and was commissioned in March 1972. It doubled the company's tinplate manufacturing capacity.

The second-largest use for tin is in the manufacture of solders. Between 1,500 and 1,800 tonnes of tin are used annually for this product. Important Canadian users of tin for this application are The Canada Metal Company, Limited, Federated Genco Limited, Kester Solder Company of Canada Limited, Toronto Refiners and Smelters Limited, Tonolli Company of Canada Ltd., Metals & Alloys Company Limited and Cramco Alloy Sales Limited. Bronze, a copper-lead-tin alloy, is also produced in Canada, chiefly by The Noranda Copper Mills Limited and Anaconda Canada Limited.

World developments

More than 75 per cent of the world tin mine output is derived from alluvial deposits by dredging and hydraulic mining methods. Leading countries in this field are Malaysia, Thailand, Indonesia and Nigeria. Lode mines account for most of the tin output of Bolivia, Australia, Britain and South Africa. Some 12 other countries of the western world produce small amounts. Countries of the communist and socialist blocs, notably The People's Republic of China and the U.S.S.R., are also important producers. Statistics from these states are not available but their total production is estimated to be in the range of 35,000 to 40,000 tonnes annually.

Total noncommunist world output of tin-in-concentrates in 1975 was estimated at 172,600 tonnes by the International Tin Council. This is about 8,000 tonnes less than in 1974 and is the direct result of not only much lower demand and export controls, but of a steady and continuing decline in output in existing countries due to a low level of investment in the tin extractive industry. Exports of metal from China, however, increased from 10,500 tonnes in 1974 to 14,500 tonnes in 1975, thus compensating for some of this shortfall.

Concentrating processes for alluvial and most lode tin are chiefly based on relatively simple gravity separation methods that produce concentrates ranging from 50 to 76 per cent tin. Typical concentrates as delivered, for example, to Indonesia's Mentok smelter in 1974 graded 65 to 72 per cent tin. Lode mining companies in Australia, South Africa and Britain have recently installed flotation cells in their beneficiating plants to complement gravity separation and improve the recovery of other metals, as well as some very fine tin. Another trend now being implemented is split production of a high-grade concentrate and a low-grade concentrate. By producing some low-grade concentrates of approximately 30 per cent tin, an overall improvement in recovery is achieved that may compensate for the substantially-higher smelting charges which must be incurred.

Malaysia. Malaysia, the largest world tin producer, had a production of tin-in-concentrates of 64,364 tonnes in 1975, compared with 68,122 tonnes in 1974. This is the fourth consecutive annual decrease in production from a peak of 76,830 tonnes achieved in 1972. The record Malaysian production was 79,400 tonnes in 1941. At the end of 1975 Malaysia recorded production from 910 mining units, which included 55 dredges and 810 gravel pump operations. Dredges account for 33 per cent of production, gravel pumps for 54 per cent and hand-sluicing and panning for the remaining 13 per cent. The labour force was 39,736, a decrease from 44,050 in 1974.

Malaysia has two tin smelters that jointly produced 83,070 tonnes of tin in 1975 from domestic and imported ores, compared with 84,394 tonnes in 1974. As a result of export controls, however, exports dropped by 9.1 per cent to 77,940 tonnes and the unit value dropped by 12.5 per cent to M$ 15,475 per tonne, or M$ 936 per picul, contributing to a 20.4 per cent decline in Malaysia's export receipts from tin in 1975. Besides export controls, problems confronting the industry in 1975 were the increasingly low-grade tin-bearing ores and the sharply rising production costs, both set against a background of declining tin prices.

Table 1. Canada, tin production, imports and consumption 1974-75

	1974		1975p	
	(tonnes)	($)	(tonnes)	($)
Production				
Tin content of tin concentrates and lead-tin alloys	324	2,565,155	283	2,192,000
Imports				
Blocks, pigs, bars				
Malaysia	818	6,750,000	1,637	11,798,000
United States	3,459	26,697,000	1,181	8,830,000
Australia	108	913,000	484	3,346,000
Brazil	528	4,140,000	448	3,212,000
Netherlands	111	975,000	257	2,213,000
People's Republic of China	190	1,261,000	191	1,367,000
Belgium-Luxembourg	—	—	102	865,000
United Kingdom	212	1,696,000	97	769,000
Other countries	130	811,000	94	676,000
Total	5,556	43,243,000	4,491	33,076,000
Tinplate				
West Germany	—	—	4,810	2,238,000
United States	3,486	1,395,000	1,704	769,000
United Kingdom	174	136,000	182	141,000
Japan	22	11,000	—	—
Total	3,682	1,542,000	6,696	3,148,000
Tin, fabricated materials, nes				
United States	101	562,000	180	232,000
United Kingdom	2	15,000	11	37,000
West Germany	5	52,000	1	5,000
Other countries	5	14,000	1	7,000
Total	113	643,000	193	281,000
Exports				
Tin in ores, concentrates and scrap[1]				
United States	205	929,000	801	1,713,000
United Kingdom	165	315,000	165	206,000
Mexico	113	305,000	52	145,000
Other countries	103	186,000	34	114,000
Total	586	1,735,000	1,052	2,178,000
Tinplate scrap				
United States	7,437	663,000	6,285	434,000
Peru	—	—	32	3,000
Spain	802	100,000	—	—
Other countries	354	136,000	—	—
Total	8,593	899,000	6,317	437,000

Table 1. (concl'd)

	1974		1975^p	
	(tonnes)	($)	(tonnes)	($)
Consumption				
Tinplate and tining	3,189		2,407	
Solder	1,735		1,525	
Babbit	238		152	
Bronze	185		112	
Other uses (including collapsible containers, foil, etc.)	78		119	
Total	5,425		4,315	

Source: Statistics Canada.
[1]Much of the scrap is gross weight of material with low tin content.
^{p}Preliminary; — Nil; nes Not elsewhere specified.

Table 2. Canada, tin production, exports, imports and consumption, 1965-75

Year	Production[1]	Exports[2]	Imports[3]	Consumption[4]	
				Recorded	Unrecorded
		(tonnes)			
1965	171	219	5,073	4,910	
1966	322	342	4,322	5,052	
1967	198	331	4,621	4,889	
1968	163	119	4,369	4,319	
1969	131	313^e	5,024	4,349	450^e
1970	120	272^e	5,111	4,554	500^e
1971	144	296^e	5,104	4,056	800^e
1972	160	379^e	5,906	4,760	700^e
1973	132	127^e	5,465	5,235	100^e
1974	324	550^e	5,556	5,425	50^e
1975^p	283	310^e	4,491	4,315	. .

Source: Statistics Canada.
[1]Tin content of tin concentrates shipped, plus tin content of lead-tin alloys produced. [2]Tin in ores and concentrates and tin scrap, and after 1969 also re-exported primary tin. [3]Tin metal. [4]Consumption-officially unrecorded, includes consumer stock changes.
^{p}Preliminary; . . Not available; ^{e} Estimated by Mineral Development Sector, Department of Energy, Mines and Resources, Ottawa.

Prices of mining equipment rose substantially and the cost of diesel fuel, which accounts for 30 to 40 per cent of total operating costs of the gravel pump mines, increased by 11 per cent while the cost of electricity increased by 28 per cent.

Government officials like to point solely to a direct relationship between the lack of incentives for investment and the price of tin, which may be an oversimplification of the problems. Industry also focussed attention on the high taxes imposed on the tin mines which also includes the Surcharge (Exports of Tin) Order imposed as part of an anti-inflation package on April 23, 1974 and not repealed or modified during the interim. In total, the export duty and surcharge amounted to about 21 per cent of the cost of production in 1975 according to the President of the Perak Chinese Mining Association.

An improvement is forecast for 1976 with a 6 per cent increase in the production of tin-in-concentrates to 68,000 tonnes and tin metal exports of 80,000 tonnes. Production of metal may decrease, however, since Malaysian smelters will no longer be processing concentrates from Indonesia after May 1976.

In the long term, Malaysia will maintain a dominant role as a tin supplier, with two new potential sources; offshore mining, and deep-seated alluvial deposits. The latter would require the construction of a new generation of deep dredges.

One promising new area is in the Kuala Langat forest reserve, which has estimated reserves of slightly over 300,000 tonnes of tin ore and is referred to as Malaysia's second Kinta Valley. The presence of offshore deposits was established off the west coast of Malaysia, particularly the States of Perak and off the Malacca coast. Exploratory drilling programs were instituted in 1974 and continued in 1975. It is expected that significant offshore mining will become a reality in the early 1980s.

The government issued guidelines for the long-term Malayanisation of the tin-mining industry, with a target of 30 per cent Bumiputra or Malay nationals participation by 1990. At present Malay participation is only 1 to 2 per cent.

Bolivia. Bolivia is the largest producer of tin from lode mines. A small proportion of annual output is derived from dredging operations. For 1975, Bolivia's mine production is estimated at 28,324 tonnes, of which approximately 20,000 tonnes were exported for smelting, mainly to Europe and the United States. In addition, the country's Vinto smelter, commissioned in January 1971 by Empressa Nacionale de Fundiciones (ENAF), produced 7,133 tonnes, operating near its initial rated capacity of 7,500 tpy.

The first phase of a two-phase expansion program was completed in late 1975. It raises the operational capacity to 11,000 tpy in 1976, and involved the installation of a rotary furnace and a second fuming furnace. Vinto can now treat all of the tin-bearing slag produced in the process, and also part of the slag stockpiled over the last few years. The final stage of expansion, which will raise capacity to 20,000 tpy, is scheduled to be completed by 1977. It involves the addition of two reverberatory furnaces, six thermal refining kettles and five electrolytic cells. At the completion of the final stage in 1977 total capital costs are estimated to be between U.S. $40 and U.S. $45 million.

Bolivia's top priority is the upgrading and better recovery of tin in low-grade ores. Ores throughout the country, but particularly those of the Potosi area, are mineralogically very complex and of a very fine-grained nature and therefore very difficult to concentrate. At present, the recovery from the Potosi mines is in the range of 50 to 60 per cent when producing concentrates of over 20 per cent tin. To improve overall tin recovery the following extraction scheme has been designed for the Unificada mine at Potosi. A new gravity preconcentration plant, treating mill heads of about 0.8 per cent tin, will produce concentrates of only 3 per cent tin, but the recovery will be raised to about 70 per cent. A volatilization plant will treat this low-grade concentrate and the product will be a 50 per cent concentrate with a recovery of 90 per cent or better. However, since the product of the volatilization plant, although high grade, is too "dirty" to process in a conventional tin smelter, a "low-grade tin smelter" will be constructed at the Vinto complex. The feed for the low-grade tin smelter will be a mixture (about 1 to 1) of the 50 per cent tin concentrate from the Potosi volatilization plant and concentrates from various Comibol and private mines grading about 25 per cent tin.

The Potosi volatilization plant is now under construction using technology and loans provided by the U.S.S.R. It will be completed in 1977 and at full capacity will produce about 3,500 tonnes per year of tin (7,000 tonnes per year of concentrates). Design for the "low-grade tin smelter" will be completed in 1976 and, if construction starts on schedule the same year, the smelter may be operational by 1978. In addition to tin, this smelter will produce antimony, bismuth, and some base metals. The tin producing capacity will be about 10,000 tonnes per year. The U.S.S.R. (Machinoexport), West Germany (Klockner-Industrieanlagen) and Denmark (Paul Bergsoe and Sons) will jointly construct the low-grade tin smelter. Capital costs, for the completed facility, which would include installations for the recovery of by-product metals, would be in the U.S. $40 to U.S. $50 million range.

Pending the success of the Potosi volatilization plants, plans are afoot for one or two others which could be installed to process ores, tailings and concentrates from such mines as Machacamara (at Oruro) San Jose y Queschisla, Catavi, Huanuni and Colquiri.

Table 3. Estimated world[1] production of tin-in-concentrates, 1965, 1974-75

	1965	1974	1975
	(tonnes)		
Malaysia	63,670	68,122	64,364
Bolivia	23,037	29,151	28,324
Indonesia	14,699	25,630	24,391
Thailand	19,047	20,339	16,406
Australia	3,849	10,114	9,231
Nigeria	9,547	5,455	4,652
Republic of Zaire	6,211	4,750	4,160
Total, including countries not listed	152,100	180,500	172,600

Source: International Tin Council, Statistical Bulletin.
[1]Excludes countries with centrally planned economies, except Czechoslovakia, Poland and Hungary; The People's Republic of China and U.S.S.R., are large tin producers.

Indonesia. Mine production decreased to 24,391 tonnes in 1975 from 25,630 tonnes in 1974. The metal sector continued to expand for the fourth consecutive year with an output of 17,826 tonnes in 1975 compared with 15,065 tonnes in 1974. Indonesia has an objective to reach a mine output of 27,000 to 29,000 tonnes by 1980 and to have 80 to 100 per cent of it smelted domestically.

Table 4. Estimated world[1] production of primary tin metal, 1965, 1974-75

	1965	1974	1975
	(tonnes)		
Malaysia	72,469	84,394	83,070
Indonesia	1,189	15,065	17,826
Thailand	5,524	19,827	16,630
United Kingdom	16,494	12,107	11,570
Bolivia	3,415	6,907	7,133
United States	3,097	6,100	6,090
Brazil	1,412	4,848	5,400
Australia	3,179	6,714	5,254
Spain	1,787	4,500	4,700
Nigeria	9,332	5,574	4,677
Belgium	4,232	3,418	4,562
Republic of South Africa	962	2,000	2,400
West Germany	1,427	1,384	1,306
Total, including countries not listed	148,200	177,000	174,900

Source: International Tin Council, Statistical Bulletin.
[1]Excludes countries with centrally planned economies, except Czechoslovakia, Poland and Hungary.

The Indonesian State Tin Enterprise, P.N. Timah, completed the expansion of its Peltim smelter (Mentok) on Bangka Island with the firing of the last of the three new reverberatory furnaces in December 1975. Although each reverberatory furnace has a theoretical capacity of 8,000 tpy, the practical maximum operational capacity of the system will be 18,000 tpy, and of the three old rotary furnaces 15,000 tpy. The total annual refined metal capacity of 33,000 tonnes will afford an adequate margin for domestic smelting of the expanding mine output. As of the second quarter of 1976, Indonesia will no longer ship concentrates for smelting to the Malaysian smelter at Penang.

PT Broken Hill Proprietary Indonesia is considering reopening the old Kelapa Kampit lode mine on Belitung Island. The mine was in production between 1906 and 1942. It has been partially dewatered and a pilot mill is now processing the ore from the first four levels. Some concentrates are also produced from two adjacent open pits, the Fuk Salu and Nam Salu workings. The decision on whether PT BHP Indonesia will go to full production at some 500 tonnes of ore per day should be made sometime in 1976 or 1977, depending on ore reserves, pilot test results and an agreement with the Indonesian government allowing exports.

The Kelapa Kampit mine and the surrounding primary tin deposits on Belitung Island and adjacent islands are considered by some geologists as one of the best areas in the world for primary tin mineralization.

In late 1975, Billiton reported the discovery of an important offshore tin deposit in the Pulau Tudju area off the coast of Sumatra. The company announced this success after seven years of prospecting, and plans to begin offshore dredging in 1978 at an initial annual rate of 2,430 tonnes of 70 per cent tin concentrate.

Thailand. Thailand's tin mining production decreased for the fourth consecutive year to 16,406 tons in 1975 from 20,339 tons in 1974. This sharp decline is due to the closing of Temco's tin mining operations in March, resulting in a drop of some 1,500 tons and an overall decrease in mining activities, particularly in the gravel pumps and hydraulic sector.

Dredging operations accounted for approximately 32 per cent and gravel pumps, hydraulic mining and dulang washers accounted for 54 per cent. Thailand also recorded output from several small lode mines.

Table 5. World[1] tin position, 1973-75 (and estimated 1976)

	1973	1974	1975	1976^e
	(thousands of metric tons)			
Ore Supply				
Production of tin-in-concentrates	185.3	181.7	174.9	174.0
Stocks at year's end	12.1	10.2	15.6	. .
Primary metal supply				
Smelter production of tin metal	184.7	177.2	175.2	177.0
Net supplies (+) from Sino-Soviet Bloc	(−)1.9	(+)4.9	(+)4.5	(+)3.6
U.S. Government stockpile sales	17.6	23.5	0.6	3.0^e
Buffer stock sales (+) purchases (−)	(+)11.5	(+)0.9	(−)19.9	(+)19.9^e
Primary metal consumption (I.T.C.)	212.1	199.4	172.7	190.0
Balance (Metal)	(−)0.2	(+)7.1	(−)12.3	(+)13.5
Recorded commercial stocks: at year's end	37.9	39.2	36.4	. .

Source: International Tin Council, Statistical Bulletin.
[1]Excludes countries with centrally planned economies except Czechoslovakia, Poland and Hungary.
. . not available; ^{e}Estimated.

The offshore concession of Thailand Exploration and Mining Co. Ltd. (Temco) was withdrawn in March by Thailand's Minister of Industry, "because it had failed to comply with government regulations." Temco is a Union Carbide Corporation-Billiton group partnership in which the Thai government has an 8 per cent interest. The company operated two offshore cutter suction dredges, Temco I and Temco II. The largest, the Temco II dredge, commissioned in 1971, has an annual capacity of 5 million cubic yards and was designed to operate in rigorous sea-dredging conditions. This unit, however, experienced considerable operating problems. The Temco concession was officially nationalized in April and subsequently the United States government requested the Thai government to either reconsider the offshore mining concession or pay compensation. As of the end of the year no formal agreement has been concluded on the Temco concession, although a new government body, the "Offshore Mining Organisation" (OMO), was formed and approached other companies with the objective of restarting dredging in the area. At the beginning of 1976, it was reported that thousands of people operated illegally on the rich, shallow parts of the former Temco concessions.

Late in 1975, Faber Merlin Ltd. began mining at a rehabilitated tin-tungsten lode known as the Sichon mine in southern Thailand. The objective is to achieve a capacity of 360 tonnes of tin per year and about 40 tonnes of by-product wolfram.

The Phuket smelter of the Thailand Smelting and Refining Co. Ltd. (Thaisarco) produced 16,630 tonnes in 1975 compared with 19,827 tonnes in 1974. The smelter has a capacity of 40,000 tpy and was commissioned in 1965 as a joint venture between Union Carbide (70 per cent) and the Eastern Mining Development Company (30 per cent). The last company is now jointly owned by Union Carbide and Billiton, N.V. Thaisarco decided to make its shares available to the public.

Australia. Australia is the fifth largest producer of tin in the noncommunist world and like all other major producers, its mine production declined in 1975 to 9,231 tonnes from 10,114 tonnes in 1974. The underground operations of Aberfoyle, Cleveland and Renison mines in Tasmania, and the Ardlethan mine in New South Wales, accounted for about 72 per cent of the total production. The balance of tin-in-concentrates produced in 1975 came from sluicing and dredging operations in Western Australia, New South Wales and Queensland.

Expansion plans, particularly at the Renison mine, will raise the total output of the underground mines to about 10,000 tonnes by 1976. Production at Renison increased to 3,783 tonnes in 1975 from 3,527 tonnes in 1974 despite the fact that the company curtailed production in the second half of the year as a result of export controls. Meanwhile, the company processed some low-grade ore on an experimental basis, taking advantage of the idle capacity.

Associated Tin Smelters Pty in Alexandria, Queensland produced 5,254 tonnes of tin in 1975. The rest of Australia's mine tin was exported to Malaysia and the United Kingdom for smelting.

Nigeria. Tin output in the Federal Republic of Nigeria, now all from alluvial deposits, decreased to 4,726 tonnes in 1975 from 5,455 tonnes in 1974. Nigeria's tin mining is labour-intensive, with 60,000 people engaged in this sector. Columbite is a significant byproduct of tin mining. Two bucket-wheel excavators were scheduled to be put in operation during 1975, at the Sabon Gida tinfield of Amalgamated Tin Mines of Nigeria (Holdings) Ltd. This represents a £650,000 investment, the most important in Nigerian tin mining for many years.

Tin metal production at the Makeri smelter at Jos is only from domestic concentrates and declined to 4,619 tonnes in 1975 from 5,574 tonnes produced in 1974. There was also a brief strike in February at the smelter.

Zaire. Production of tin in the Republic of Zaire has declined steadily since 1969. Production of tin-in-concentrates in 1975 was 4,160 tonnes compared with 4,750 tonnes in 1974.

Four medium-size companies are exploiting the deposits: Symetain, Cogemines, Zairetain and Kivumines. Only about 650 tonnes of tin were smelted domestically at the Manono smelter. The rest of the country's mine production is exported to Belgium (Hoboken's plant) and Spain for smelting.

Brazil. The Brazilian government approved a program of expansion of the nonferrous industry which includes the objective of self sufficiency in tin output by 1983. The projected demand would be approximately 21,000 tonnes per year. Brazilian consumption in 1975 was estimated at 4,277 tonnes compared with 3,502 tonnes in 1974. Mine production in 1975 was estimated at 4,117 tonnes (tin content) compared with 3,555 tonnes in 1974. A breakdown for 1975 is not available, but for 1974 four companies were responsible for over 73 per cent of Brazil's total mine output. The total Brazilian output reported at 5,387 tonnes (in tin concentrates of 66 per cent Sn) is divided as follows: Mineracao Brumadinho Ltda, 1,917 tonnes; Paranapenema S.A., 1,000 tonnes; Mineracao e Prospeccoes Minerais S.A., 584 tonnes; Companhia Estanifera do Brazil, 436 tonnes and miscellaneous prospectors, 1,450 tonnes.

Brazil has six smelters with a combined capacity of 14,100 tonnes per year of which the following are of importance: Companhia Estanifera do Brazil at Volta Redonda, 6,800 tpy; Companhia Industrial Amazonense at Manaus, 2,400 tpy and Mamore Min. e Metalurgia at Sao Paulo, 2,400 tpy. Bera do Brasil S.A. which operated a 1,000 tpy smelter at Sao Paulo is being closed and relocated in a new area outside Sao Paulo. Metal production in 1975 was 5,400 tonnes, with concentrate imports mainly from Bolivia and Singapore supplementing domestic sources.

Brazil's tin reserves were lately subject to much speculation, with some very high estimates gaining partial credibility. The most authoritative reports of the National Mines Department, i.e. Departamento Nacional de Producao Mineral (DNPM) have placed the total reserves at approximately 300,000 tonnes (in tin concentrates of 66 per cent Sn). Of this total 180,000 to 200,000 tonnes are reserves in the most important Rondonia placer district.

United Kingdom. Mine production in 1975 was 3,389 tonnes, a small increase over the poor record of 3,239 tonnes achieved in 1974. While Geevor Tin Mines Ltd. and South Crofty Ltd. increased output considerably, Wheal Jane Ltd. recorded a 17 per cent drop in production, mainly as a result of a substantial fall in the grade of ore treated and significant increases in production costs. The Mount Wellington mine, next to Wheal Jane, will be brought into production during the first half of 1976 at a total cost of approximately £5 million of which £800,000 is being supplied by a U.K. government loan. The Mount Wellington mine has a planned annual capacity of 6,000 tonnes per year of tin concentrates. The concentrates are expected to grade approximately 33 per cent tin. More exploration and expansion are planned in 1976 for the Wheal Jane mine and the Geevor mine. South Crofty Ltd., one of the three major lode-mining companies in Cornwall, also continued to treat ore from the small, non-profitable, Pendarves mine which it acquired in 1973.

Metal production decreased from 12,107 tonnes in 1974 to 11,570 tonnes in 1975. Most primary tin was produced by the Capper Pass smelter, Britain's principal producer since June 1973, when Williams Harvey and Co., which operated the Kirkby smelter, went into bankruptcy. Subsequently, Amalgamated Metal Corporation Ltd. kept the Kirkby plant in operation to process the accumulated tin-bearing residues and slags and was successful in paying all creditors.

Tin consumption was 14,430 tonnes in 1975, the lowest in 50 years. Consumption in 1974 was 16,730 tonnes down from 18,358 tonnes in 1973. The largest decreases by use were recorded in tinplate, solder and chemicals.

United States. Lost River Mining Corporation Limited signed a long-term agreement in February 1974 with the Bering Straits Native Corporation of Alaska with respect to land and development rights pertaining to the company's fluorite-tin-tungsten property on the Seward Peninsula. The Bering Straits group has expressed an interest in participating in the financing of the estimated $80 million project (1974 dollars) and in the mine construction contracts. The agreement also covers environmental protection, native hiring and management training, and an option to acquire equity interest in any futures mines. Commencement of construction is dependent on obtaining satisfactory financial arrangements.

Only an insignificant mine output of tin is recorded for the continental United States. The Texas City smelter, which has an installed capacity of 10,000 tpy, produced approximately 1,800 tonnes from concentrates, mainly imported from Bolivia.

The Republic of South Africa. This country ranks tenth in the noncommunist world in tin mine production and with the exception the United Kingdom and Brazil is the only country which increased production; from 2,490 tonnes in 1974 to 2,771 tonnes in 1975. This increase comes as a result of substantial improvements at the two operating companies, Rooiberg Minerals Development Co. Ltd. and Union Tin Mines Ltd. A third company, Zaaiplaats Tin Mining Co. Ltd., which produced about 331 tonnes in 1975, may be closed soon. Reserves at the Union Tin Mine are declining rapidly and the company's report for the year to end-June 1975 states that the remaining life of the mine will probably not be longer than two years.

South-West Africa produced 650 tons in 1975 compared with 700 tons in 1974. About 70 per cent of the combined output of the two countries is smelted at the Zaaiplaats smelter near Potgietersrust and the remainder is exported as concentrates, mainly to the United Kingdom and Spain. The Potgietersrust smelter has an annual capacity of 3,000 tonnes.

Rwanda. The country produced approximately 1,250 tonnes of tin in 1975. Operations of the principal producer, Minetain S.A. Exploration are being intensified and a new program rationalizing production and uniting a number of companies has been proposed.

Almost all output is shipped to Belgium for smelting. According to Geomines annual report, the establishment of a tin smelter with an initial nominal capacity of 3,000 tpy is planned for Société des Mines du Rwanda (Somirwa).

Zambia. Zambia, like many other African countries, has only very small tin production, estimated at 24 tonnes in 1975. Large deposits of tin and tantalite have been discovered between Batoka and Livingstone in the south of the country and this discovery may lead to the opening of an open-pit mine.

Burma. Burma, currently producing about 600 tonnes of tin a year, compared with 6,000 tonnes annually prior to the Second World War, has begun a planned program of mineral exploration with foreign assistance. The country has received $6.5 million in aid from the United Nations Development Program for the period 1974-78 for a variety of projects, including a geological survey, and onshore and offshore exploration for tin and tungsten deposits. The U.S.S.R. and West Germany also contributed to projects aimed at the rehabilitation and expansion of tin-tungsten mines. A loan from West Germany was granted to finance a substantial increase in output from the Myanma's Heinda mine to take effect sometime in 1976.

Laos. Tin production in Laos in 1975 was estimated at 522 tonnes, down significantly from the 612 tonnes produced in 1974. It is believed that a large part of the output comes from the Phon Tiou and Nong Sun mines.

India. The country consumes approximately 3,000 tonnes of tin annually but has no recorded production. An important tin find was announced in 1975 in the Bastar area of Madhya Pradesh district. It will be investigated and surveyed under a U.N. development program.

Mexico. Although its domestic mine production is very small, 164 tonnes in 1975, Mexico produces metal from imported concentrates for 60 per cent of its internal consumption. The Estano Electro, Tlalnepantla smelter has an annual capacity of 1,300 tonnes and will be modernized, using Soviet technology on vacuum refinement of tin.

Belgium. The Hoboken smelter has a rated capacity of 18,000 tonnes per year. However, it produced only 4,562 tonnes of tin in 1975 and 3,418 tonnes in 1974. Imports of concentrates are from Zaire, Rwanda and several small African producers.

France. Compagnie Minière de Saint-Renan, France's only tin mining operation, produced only 51 tonnes of tin-in-concentrates in 1975 compared with 142 tonnes in 1974. Since an investigation of all known deposits on the property proved disappointing, the company terminated production in the last quarter of 1975.

Spain. Mine production was 553 tonnes in 1975 but metal production was an estimated 4,700 tonnes, mainly from concentrates imported from Zaire and Bolivia, plus smaller quantities from some 10 other countries. Spain originally planned substantial increases in mining for the period 1974 to 1980. Most of the plans for new mines have been deferred. The Penouta (Orense Province) tin mine originally planned for 1976, with an annual output of 1,500 tonnes of 67 per cent tin concentrate, should be in full production by 1980.

There are a few small tin refineries in Spain but the only smelter of importance is the Villagarcia de Arosa plant of Metalurgica del Noroeste where capacity is now being increased from 2,500 tpy to approximately 6,500-7,000 tonnes per year. The new plant is being built by Lurgi Gesellschaft of Frankfurt, West Germany.

West Germany. Metallgesellschaft A.G.'s Berzelius smelter in Duisburg, with a capacity of 3,600 tons, produced 3,108 tonnes of tin and tin content of alloys in the year ended September 30, 1975, a slight decrease from the previous year. West Germany is investing U.S. $750,000 in the development of a new low-pollution secondary tin recovery process which could cut the country's reliance on tin imports.

The People's Republic of China. China is a significant world producer and exporter of tin. Production has been estimated at 20,000 tonnes annually. Output is primarily from the lode deposits in the Kochui district in Yunnan and the placer deposits of the Fuhochung area in Kwangsi. In 1974 China exported about 9,481 tonnes of tin, and in 1975 exports increased to approximately 14,500 tonnes.

According to a Japanese report, China may substantially boost its tin output, particularly if it introduces methods for better recoveries of tin from complex ores.

Soviet Union. U.S.S.R. production is currently estimated at slightly below 20,000 tonnes per year and the country normally imports a further 4,000 to 5,000 tonnes. Soviet imports in 1975, however, reached an unusually high quantity of 9,654 tonnes. Since there was a corresponding decrease in imports by other COMECON countries, some of this material may have been redistributed within the bloc.

Exploration for tin holds a high priority in the U.S.S.R., and several tin-bearing regions have been outlined. Exploitation, however, must wait for the provision of better transportation, notably the completion of the Baikal-Amur railway. New mines and a major new concentrator have been commissioned during 1975 in the Sikota Alin mountain district and the nearby Krustalnii enrichment complex in the Pacific area of the U.S.S.R.

The international tin agreements

Tin is the only metal for which there is formal cooperation between producer and consumer interests and among governments to rationalize problems of supply and demand and attenuate, to a certain extent, excessive price variations. The large mine producers of tin are developing countries with little consumption, and the largest consumers are the major industrial countries. A common interest in market stability in the post-war period led first to a study group and then to the First International Tin Agreement in 1956 under the auspices of the United Nations. The International Tin Council was formed to implement this agreement.

The First International Tin Agreement was in force from July 1, 1956 to June 30, 1961 and the second from July 1, 1961 to June 30, 1966. The third and fourth international tin agreements came into force on July 1, 1966 and on July 1, 1971, respectively. The current agreement will expire on June 30, 1976. Negotiations leading to the implementation of the next five-year international agreement were held in Geneva in May 1975.

The main objective of The International Tin Council is the consideration of short-term problems of supply and demand and pricing. Decisions that affect supply and price, however, are made with regard to long-term trends. Consumer and producer members have an equal number of votes in the governing body, The International Tin Council. Canada is a signatory to the agreement and, in proportion to its consumption, has 42 of the total of 1,000 votes allocated to consumers. The 22 consumer members and seven producer members accounted for 65.2 per cent of recorded world consumption in 1975. The total does not include U.S.S.R. consumption as its data is not available, even though the U.S.S.R. is a member country. The United States is the main non-member country among Western consuming countries. Its consumption of tin in 1975 was 55,798 tonnes, of which 43,618 tonnes were primary tin.

Producer members are Australia, Bolivia, Indonesia, Malaysia, Nigeria, Thailand and The Republic of Zaire. Counted together, producer and consumer members of the Council account for 90.7 per cent of the noncommunist production of tin-in-concentrate, of which the seven producer members account for 87.8 per cent.

Members of The International Tin Council established a buffer stock which at the beginning of the Fourth Agreement had direct financial resources equivalent to the value of about 20,000 tonnes of tin, but due to continuous increases in the tin price these resources were only equivalent to the value of about 12,500 tons at the end of 1975. In addition to the above, the Council has the authority to borrow on the commercial markets, using tin held by the buffer stock as collateral.

The operation of the stock, to which only producer members contributed until recently, is vested in a manager appointed by the council, and responsible to the executive chairman of the council. The ranges of permissible prices are set by the tin council and within this framework the manager of the buffer stock may use discretionary judgement to buy or sell tin metal, but not concentrates, on major markets to modify price fluctuations and ease supply problems.

Council may impose export controls to curtail metal supply if tin in the buffer stock exceeds 10,000 tonnes and other conditions appear to warrant such action. Financial resources of the buffer stock were bolstered significantly by voluntary contributions from the Netherlands since 1971 and France since 1973 in proportion to their consumption and votes on the Council.

The buffer stock manager operates within price ranges designated as the lower, middle, and upper sector as shown in the accompanying tabulations. Under the first three agreements the buffer stock manager was directed to buy only in the lowermost sector and sell only in the uppermost sector, with no action in the middle sector except under special instruction which was rarely granted. Under the Fourth Agreement, however the buffer stock operations are more effective since, under a much more flexible system, the manager is given authority to both buy and sell in the lower and upper sectors as long as he remains a net buyer in the lower sector and a net seller in the upper sector. The manager was also given permission to operate temporarily in the middle sector under special provisions.

Export controls were invoked on a number of occasions, most recently between January 19, 1973 and September 30, 1973 and again on April 18, 1975. These were still in force at the end of the year. Export quotas for the producer members of the International Tin Council are set in proportion to historical export statistics for selected preceding quarters. The export controls are established on a quarterly basis. Once a maximum permissible level is set for a given quarter it cannot be lowered, but controls can be lifted at any time. Controls can be tightened in each successive quarter if market deterioration warrants this action. For each occasion, special full sessions of the International Tin Council must be held. External borrowing is also approved at full sessions of the Council. Before setting the total export quota, the Council examines estimates of production and consumption and takes into account the quantity of tin metal and cash held in the buffer stock, the quantity, availability and probable trend of other stocks, including G.S.A. disposals; the trade in tin, the current price of tin metal and other relevant factors.

The severity of the world-wide recession and the rapidity with which it followed the commodities boom of 1973-1974 obliged the Council to introduce export controls during the April 1975 session. At the same time, the Council called up the remaining balance of contributions, that is £13.5 million, due to the buffer stock from the producing countries.

The export control periods during 1975 were as follows:

(a) April 18 to June 30 (74 days), with a total permissible export tonnage of 26,560 tonnes representing an 18 per cent cutback from the estimated figures on production.

(b) July 1 — September 30, with a total permissible export tonnage of 33,000 tonnes.

(c) October 1 — December 31, with a total permissible export tonnage of 35,000 tonnes.

(d) January 1 to March 31, 1976 was declared the fourth consecutive control period. The permissible export tonnage was set originally at 32,000 tonnes and adjusted to 32,835 tonnes on March 12, 1976.

The fifth International Tin Agreement.

The Fourth International Tin Agreement will expire on July 1, 1976. The UNCTAD conference, with Canada as a participant, that established the text of the Fifth International Agreement was held in Geneva from May 20 to June 21, 1975.

The new agreement will be open for signature at the United Nations Headquarters in New York from July 1, 1975 to April 30, 1976 by parties to the Fourth International Tin Agreement and by governments invited to the United Nations Tin Conference of 1975. The United States is expected to join for the first time.

The Fifth Agreement will enter into force when ratified by at least six producing countries holding among them at least 950 of the 1,000 votes allocated to the seven producers, and by at least nine consuming countries holding among them at least 300 of the 1,000 votes allocated to the 28 consuming countries. The ratification system for the producers could be construed as a weakness of the new agreement, since any one of the seven major producers may prevent its implementation.

The Fifth Agreement is designed primarily to prevent excessive fluctuations in the price of tin, to help increase the export earnings from tin and to secure an adequate supply of tin at prices fair to consumers and remunerative to producers. The participating countries also recognized that it is in the spirit of the new international economic order.

The Fifth Agreement, like previous international tin agreements, incorporates two main operational mechanisms; the use of a buffer stock, and the application of export controls when necessary in order to adjust supply to demand. The operation of the buffer stock is related to a floor and ceiling price, the range between the floor and ceiling prices being divided into three sectors. The floor and ceiling prices are to be expressed in Malaysian ringgit or in any other currency the International Tin Council may decide. The initial floor and ceiling prices under the Fifth Agreement will be those in force on the termination of the Fourth Agreement.

Contributions by producing countries to the buffer stock must amount to the equivalent of 20,000 metric tons in cash, tin metal or a combination of both, as determined by the Council. The equivalent of 7,500 metric tons is due when the agreement goes into effect, and the remainder as and when determined by the Council. An important change in regard to valuation of tin in connection with contribution to the buffer stock is that contributions to the buffer stock made in cash after the start of the Agreement will be made at the floor price prevailing at that time and not, as under the Fourth Agreement, at the floor price on the entry into force of the agreement. This will reduce any erosion of the authorized size of the buffer stock which might otherwise result from increases in the floor price during the life of the agreement.

The Fifth Agreement provides for additional contributions to the buffer stock over and above those required from producing countries. As in the Fourth Agreement, contributions may be made by any country invited to the Conference; such voluntary contributions are made under the Fourth Agreement by France and the Netherlands. However, a major innovation in the Fifth Agreement is that an amount of up to the equivalent of 20,000 metric tonnes of tin metal is an implied overall target for contributions from consuming countries participating in it. After the agreement has been in operation for two and a half years, the Council must review the results obtained in regard to these additional contributions. In the light of its review it may decide that a conference be convened within six months to renegotiate the agreement.

As under the Fourth Agreement, the Fifth Agreement provides that the Council may also borrow for the purposes of the buffer stock on the security of the tin it holds. Furthermore, in the event of any other financial resources becoming available to the Council (for example, directly from international financial organizations), the Council may modify the arrangements concerning the size and financing of the buffer stock.

The Council has the task of keeping under review and studying the tin situation, including specified factors. The Council may at any session review the price range and in so doing must take these specified factors into account. An innovation in the Fifth Agreement is the specific mention of production costs among those aspects which are to be the subject of continuing study.

A new provision allows the Council, in the event of a shortage, to make recommendations to producing countries on appropriate measures, not inconsistent with other international agreements on trade, to ensure that preference as regards the supply of available tin is given to consuming countries participating in the Agreement. These provisions are designed to be a counterpart to the provisions for export control in times of actual or expected surplus of tin on international markets.

General Service Administration stockpile

An important stockpile of tin is that held by the United States in its stockpile of strategic and critical materials. This stockpile held about 348,500 long tons of tin in 1962, before disposals of tin deemed to be in excess of strategic requirements began. By July 1, 1968 when commercial U.S. stockpile sales were suspended these stocks were down to 257,524 long tons. Minor tin sales continued between 1968 and 1973 under the program of the United States Agency of International Development (AID). In June, 1973 commercial sales were resumed and the level of sales surged.

The stockpile objective was raised on March 28, 1969 from 200,000 to 232,000 long tons. The original tin stockpile authorization was not repealed in 1969 when congress raised the objective to 232,000 long tons and in August, 1974 the General Service Administration (GSA) officially announced that the extra 32,000 long tons would be available for disposal, increasing the total of 49,897 long tons.

Sales of tin by the GSA from the stockpile in 1974 were 23,137 long tons almost all of which took place in the first half of the year. Thereafter, disposals declined substantially in the face of rapidly weakening demand brought about by the intensifying of the world-wide recession. For all of 1975 only 575 long tons were sold, leaving a balance of 6,315 long tons authorized for disposal at the end of the year.

During 1974 and 1975, the GSA sought Congressional authorization for the release of a further 100,000 long tons of tin from the strategic stockpile for disposal (the earlier "Omnibus" Bill had sought the release of 191,500 long tons). The matter was kept in abeyance pending receipt from the Administration of the detailed rationale behind so substantial a reduction in the strategic objective, not only for tin, but also for other metals and materials. A study was also being made on whether or not some form of economic stockpile of certain strategic and critical resources, including tin, should be established within the United States.

In March 1975, following a recommendation made in a classified report prepared for the Joint Chiefs of Staff, Congress "postponed indefinitely" consideration of the further release of tin from the strategic stockpile.

Uses

Tin metal is unequalled as a protective, nontoxic, hygienic coating on steel. The manufacture of tinplate represents the largest market for tin. Approximately 85 per cent of tinplate is used by the can-making industry. Available world data indicate that 71,300 tonnes of tin were used in 1975 for the production of 11.9 million tonnes of tinplate, compared to 85,800 tonnes used to produce 14.6 million tonnes in 1974. The tin coating on steel varies with the product mix of tinplate plants, from 0.25 pounds per base box (5.6 g/m^2) for electrolytic tinplate, up to 1.25 pounds (28 g/m^2) for the hot dip process. Tinplate is sold by the base box (31,360 square inches). Expressed another way, the tin content is typically about 0.6 per cent.

Tin International reports, in its January 1975 issue, that at the end of 1974, 108 electrolytic tinning lines were in operation in the world, which includes all 28 important producing countries other than the U.S.S.R. and the People's Republic of China. A further 18 dual lines are installed to produce either electrolytic tinplate or "tinfree steel". Total finishing capacity is some 20 million tonnes, of which almost 98 per cent is now electrolytic. Four more high-capacity electrolytic tinplate lines were scheduled for commissioning in 1976.

The technology of can-making is changing, with better and more economic uses being made of coiled tinplate. Other developments include the use of double-reduced tinplate and of jet soldering techniques for can side-seams. A tin coat also imparts an inherent lubricity of tinplate, an important characteristic for the recently introduced deep-drawn and wall-ironed can-making process (D&I). Seamless cans could compete in the beer and beverage can market in which chromeplated steel (TFS) or aluminum have already acquired a strong foothold, increasingly replacing glass containers. Crown Cork & Steel Corporation in the United States was the first to achieve commercial production of one-piece D&I tinplate cans in 1971; in 1972 American Can Company brought into production a similar line at Edison. In Great Britain, The Metal Box Company started commercial production of D&I cans in 1973. There is currently no substitute for tinplate in most container applications involving food processing and the expansion of this market will continue, particularly in less-developed countries. Despite yearly increases in absolute quantities of containers, the utilization of tin in tinplate has remained static in the past few years mainly because of more economical, thinner application of tin coatings. In the United States the tinplate industry, for example, utilized 5.176 kg. of tin per tonne of tinplate in 1971, 4.849 kg. in 1972 and 4.504 kg. in 1973. In 1974 and 1975 the utilization was up to 4.612 kg. and 5.011 kg. per tonne of tinplate, respectively. This can be compared with the utilization of 5.954 kg. per tonne of tinplate for world average in 1974 and 6.016 kg. in 1975. While most processed food products are now packed in cans manufactured from electrolytic tinplate, demand for hot-dipped (H.D.) tinplate material for canning highly corrosive foods such as fish remains strong in some countries. In the developed countries, H.D. tinplate is being increasingly replaced by electrolytic, particularly bi-differential, tinplate, which carries a heavier coating on one face than on the other.

After tinplate, solders are the second-largest tonnage users of tin; estimated at 24.5 per cent in the United States, 37.1 per cent in Japan and 14.7 per cent in West Germany in 1975.

The common solder used, in side seams of tin cans, for example, consists of 60 to 70 per cent tin. For soldering galvanized metal (e.g. in the automotive industry) solders with 50 to 60 per cent tin are commonly used, since they possess the best "wetting" characteristics.

Uses for tin solder (60-63 per cent Sn) in the electronic industry are growing rapidly; tin remains unchallenged as the means for interconnecting components, giving utmost reliability. New applications are the mass production of "tailormade" preforms based on discs and washers punched from foil and the use of a tin-lead powder and flux mixture that fuses when heat is applied. Tin and tin-rich coatings are also widely used to ensure highest solderability.

Soft solders are used to join side seams of cans (2 to 3 per cent Sn) and as lead-rich body-filling solders (2 per cent Sn) in the automotive industry. Automobile radiator cores are another important application. This market could run into some stiff competition with the announcement by some large European radiator manufacturers that they have solved the problems of mass-producing aluminum radiators. Use of solders in plumbing is important but is not increasing in proportion to gains in the construction industry because of the increased use of PVC (polyvinyl Chloride) plastics. In 1974 the average ratio of tin to lead used in solders by the U.S. industry was 1 to 3.5.

Tin is being increasingly used with silver in low-temperature soldering applications. Comparisons of the mechanical properties of 95 per cent tin-5 per cent silver solders with 80 per cent lead-20 per cent tin solders, show that both the ultimate tensile strength and the shear strength of the silver-containing solders are approximately twice those of the lead-tin products. The silver solders are also about 30 per cent harder, and elongate less than one-fourth as much as the lead-tin solders when the end products have to withstand stress, impact or heat. Also, tin-silver solders are non-toxic, which is an essential consideration for joints that come in contact with food or drink. Applications today vary from plumbing, heating, refrigeration and air conditioning, to food service and processing utensils, holloware and the electronics industry. Because of the non-toxicity of tin-silver solders, this application could result in significant increases in tin and silver usage in countries where the laws on toxicity might be made more stringent.

The alloy applications of tin have a long tradition. Babbit (usually 50 to 91 per cent tin) and white metal alloys (e.g. 10 to 15 per cent tin and 4 to 12 per cent antimony) are used in bearings and so are aluminum-tin alloys, which have a higher fatigue strength. Newer bearing materials include chromium-and beryllium-inoculated, tin-base alloys offering markedly improved mechanical properties. Copper-tin alloys such as bronze and gunmetal (up to 12 per cent Sn) have an average tin content of about 6 per cent and account for about 7 per cent of the world primary tin consumption; or for about 12,000 tons of primary tin, plus some 28,000 tons of secondary tin. The gunmetals contain copper, tin and zinc and sometimes lead to improved machinability. Bells are still being cast in "bell metal" (77 per cent copper-23 per cent tin). For example, on January 18, 1975 the eight-ton Liberty Bell was cast by a renowned Dutch firm. It will be shipped to Philadelphia's Independence Hall for United States bicentennial celebrations and then transferred permanently to Washington.

Continuous casting of standard shapes has reduced fabrication cost and caused renewed interest in bronze as an engineering material. A heat-treatable tin-bronze has now been developed, giving added strength.

Titanium-tin alloys bearing 2 to 11 per cent tin are used increasingly in the aerospace industry, especially in supersonic jets. For example, the British-French Concorde aircraft utilize these alloys. Terneplate, an alloy of 80-88 per cent lead and 20-12 per cent tin, has a three-century tradition as a most durable roofing material. It shows signs of revival in the United States. Other applications for terneplate are in automotive oil filters and some fixtures, and in critical body parts, for example the undersides of electric golf carts. A possible future use with large tonnage potential would be as a replacement of copper in radiator cores. A new product introduced by Hoesch in West Germany in 1973 is Galvo-Terne. It is a cold-rolled sheet, electrolytically coated with an 88 per cent lead-12 per cent tin alloy, offering attractions for corrosion-resistant car parts (gasoline tanks). It is resistant to a number of chemicals, suggesting potential uses in chemical plant applications.

Pewter is again becoming popular, for instance, pewter plate and beaker castings commemorated the 1972 Munich Olympics. Modern methods of making pewterware from rolled sheet have recently been introduced. Pewter is pure tin that has been hardened by the addition of copper and antimony; representative compositions range from 91 per cent tin, 2 per cent copper and 7 per cent antimony to 95 per cent tin, 1 per cent copper, and 4 per cent antimony. Lately, the Association of British Pewter Craftsmen drew up plans for guaranteeing a minimum of 90 per cent tin in British pewter articles. Some pewters are lead-free, but many pewters favour the addition of up to 0.5 per cent lead. Total world consumption of tin for the manufacture of pewter is now estimated to approach 5,000 tons a year.

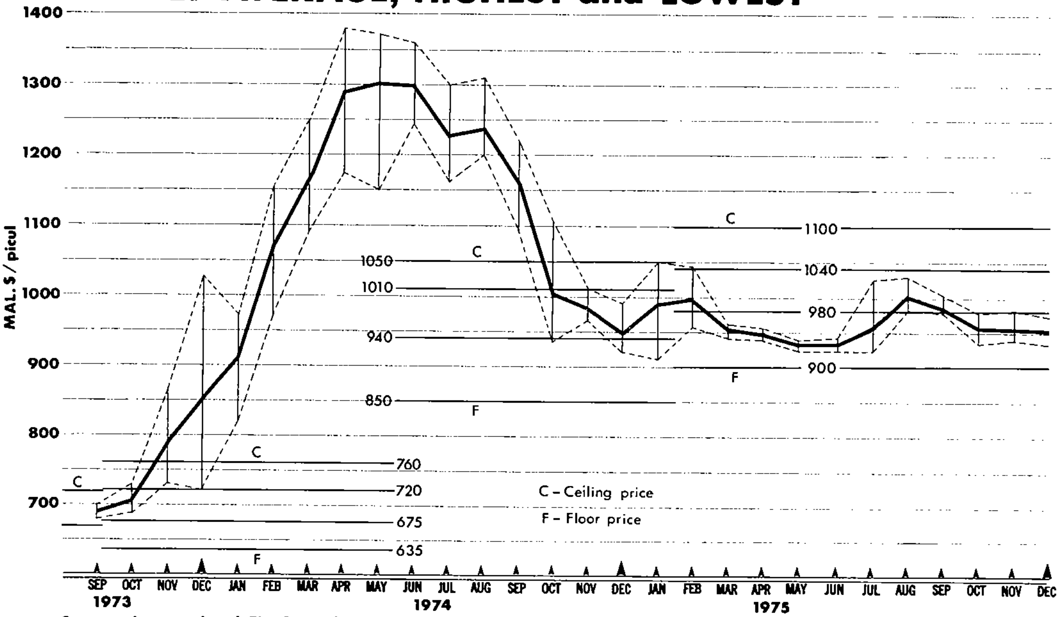
Fusible alloys of tin, bismuth, lead, cadmium and, sometimes, indium are used in safety devices such as heat fuses. Diecasting alloys of tin, antimony and copper have applications in the production of jewellery.

Tin is widely used as a minor alloying agent in other metals; for example, alloy AP (antipollution) bronze is a corrosion-resistant, copper-tin-aluminum alloy for condenser tubes in power stations operating in polluted waters. Tin accounts for 5.5 to 9.0 per cent of this alloy. Tin is a constituent in superconductive alloys such as intermetallic Nb_3Sn. Tin is also used in special protective coatings, particularly as a tin-nickel alloy electroplate which has excellent corrosion resistance, high hardness and the power of retaining an oil film.

Lead-calcium-tin alloys are now being introduced in battery manufacturing, a market long served almost exclusively by antimonial lead. Five alloys are available with tin content ranging up to 1.3 per cent.

A relatively new application is the use of small quantities of tin (approximately 0.1 per cent) in cast iron for engine blocks and crankshaft and rear-axle assemblies. Adding tin assures a uniformily hard, wear-resistant and thermally stable perlitic structure in the castings. Current consumption for this usage is estimated at 1,000 tons a year. Tin has also an application in powder metallurgy, primarily for sintered bronze bearings (sealed, self-lubricating). A new application is powder-sintered, bronze-teflon bearings. Tin plus copper is replacing other metallic additions to iron powders to improve the quality of conventionally sintered iron alloys, but only a substantial reduction in the price of tin powder could lead to a large market expansion for such products. Some encouragement in this field is provided by recent experiments in West Germany on the use of water-atomized powder produced directly from tinplate scrap.

TIN PRICE PENANG EX-WORKS: MONTHLY AVERAGE, HIGHEST and LOWEST



Source : International Tin Council

Monthly tin prices in 1975

	London Metal Exchange			New York			Penang		
	Highest	Lowest	Average	Highest	Lowest	Average	Highest	Lowest	Average
	Cash — £ per metric ton			Prompt — ¢ per lb.			Ex-works — M$ per picul		
Jan.	3,415.0	3,025.0	3,252.3	378.25	336.00	363.76	1,050,00	910.00	989.89
Feb.	3,295.0	3,000.5	3,149.3	375.25	368.50	372.04	1,043.00	955.00	996.77
Mar.	3,081.5	3,001.5	3,049.9	370.25	362.75	366.04	960.00	940.00	954.35
Apr.	3,057.5	2,971.0	3,007.1	362.50	345.75	354.11	955.25	938.00	947.92
May	2,986.0	2,959.0	2,970.8	345.50	339.25	342.54	938.00	923.13	932.69
June	3,115.5	2,964.0	3,035.9	348.00	334.50	342.49	941.63	923.13	933.66
July	3,166.5	3,071.0	3,107.2	346.25	327.00	333.32	1,025.00	923.00	956.04
Aug.	3,262.5	3,125.5	3,189.4	337.50	325.75	331.83	1,029.38	981.00	1,001.13
Sept.	3,188.5	3,106.5	3,134.5	333.50	314.50	322.77	1,005.75	979.00	987.38
Oct.	3,124.5	3,003.0	3,079.2	324.50	319.00	321.95	979.00	935.13	957.03
Nov.	3,096.0	3,017.5	3,054.2	331.00	313.00	324.03	982.25	938.00	956.29
Dec.	3,103.0	3,019.5	3,055.7	307.25	300.75	303.02	974.00	935.00	953.50

Source: Tin International

Pure tin is used in collapsible tubes, especially for pharmaceutical products. Tin is used in conjunction with the manufacture of glass, through the "float process", in which a continuous ribbon of glass floats along the surface of a bath of molten pure tin. The process was introduced by Pilkington Brothers (U.K.) in 1959 and has now completely superceded the plate process for making high-quality flat glass.

Tin is also marketed as tin oxide for polishing applications; a newer use of tin oxide is in the manufacture of conductive glass and glass resistors.

Tin is used widely in organotin compounds and inorganic tin compounds. Chemicals, however, account for consumption of 5,000 — 10,000 tons, much of which comes from secondary tin. Growth potential from this modest base is excellent. The main uses of organotins are as: dioctyltin stabilizers for PVC; triphenyltin fungicides in agriculture; and tributyltin in industrial biocides and disinfectants. Inorganic compounds stannous chloride and stannous sulphate, as well as sodium stannate and potassium stannate, are used as electrolytes in the tin-plating process. The chloride also stabilizes the colour and perfume of soap. Stannic oxide is an opacifier in enamels. Stannic chloride is a basic chemical in the manufacture of the organotin compounds. Under development is the use of organotin chemicals as biocidal compounds to combat tropical diseases; for example, schistosomiasis (blood flukes) by eliminating the main carrier, the water snail.

Tin chemicals are used as highly efficient catalysts in polyurethane foam technology and in the construction industry, and as catalysts in silicone elastomers, also known as semiplastic sealants; a rapidly expanding application. Organotins have outstanding stabilizing properties for the production of PVC compounds and roofing materials, as well as in the packaging industry.

The high-purity tin produced in Canada by Cominco, 59 grade (5-9's) (99.999 per cent) and 69 grade (6-9's) (99.99 per cent) is used mostly in metallic form in the electronics industry. Some is used to produce semiconductors such as a tin-lead telluride for advanced solid-state radiation detection devices. Tin is reclaimed by M.&T. Products of Canada Limited in the form of potassium stannate and is used directly in electroplating.

Outlook

World mine production of tin has been on a steady decline since 1972, from a peak of 195,300 tonnes to 174,900 tonnes in 1975. It is almost certain that this trend will continue in 1976 and possibly in 1977. Furthermore, there are no prospects of large increases in mine output in the next few years.

This unprecedented decline can be chiefly attributed to economic and political conditions in major producing countries that are not conducive to investment in the tin industry. Furthermore, some tin-producing countries have higher priorities than the tin industry for reinvestment of funds generated by this industry.

Land-use conflict, a longer term problem confronting certain tin producing countries where alluvial tin deposits are located in agricultural areas, will have to be resolved with the painful choice between tin or agricultural production. This is an especially serious problem in areas where prime agricultural land is in short supply.

The fact that the worrisome condition of supply of primary tin did not have a pronounced effect on consumption in the last few years is due to three factors: the fortuitious availability of tin released from the United States stockpile, the sharp drop in demand in the period from late 1974 to early 1976 and exports from China which were higher than originally forecast.

Consumption is generally forecast to recover to normal levels in 1976 and thereafter to increase between 2 and 4 per cent per year. The rate of growth depends on the underlying strength of the recovery as world economies move out of the deepest recession experienced in over two decades, and also on the levels of substitution for tin in the canning industry. The inescapable conclusion is that releases by the GSA from the stockpile in the United States must continue to take place and that net exports from the Sino-Soviet Block should increase substantially but the latter will remain an enigma. If these two events do not take place there will be very serious problems in supply that may be experienced as early as 1977.

China was a large and important exporter of tin in 1974 and again in 1975, but there are some serious doubts as to whether it can increase, or even maintain, a high level of exports in the future. The forecast therefore is for fairly good prices during the recovery year of 1976, moderated by significant sales of tin from the buffer stock of the International Tin Council (almost 20,000 tonnes were accumulated in 1975). Prices in 1977 and 1978 should be very strong, unless some unusual, depressing circumstances prevail in world economies.

Table 6. Price ranges in tin agreements

Period of operation	Floor Price	Sector Lower	Sector Middle	Sector Upper	Ceiling Price
			(£/long ton)		
1 July 1956-22 Mar. 1957	640	640-720	720-800	800-880	880
22 Mar. 1957-12 Jan. 1962	730	730-780	780-830	830-880	880
12 Jan. 1962-4 Dec. 1963	790	790-850	850-910	910-965	965
4 Dec. 1963-12 Nov. 1964	850	850-900	900-950	950-1000	1000
12 Nov. 1964-6 July 1966	1000	1000-1050	1050-1150	1150-1200	1200
6 July 1966-22 Nov. 1967	1100	1100-1200	1200-1300	1300-1400	1400
22 Nov. 1967-16 Jan. 1968	1283	1283-1400	1400-1516	1516-1633	1633
16 Jan. 1968-2 Jan. 1970	1280	1280-1400	1400-1515	1515-1630	1630
			(£/metric ton)		
2 Jan. 1970-21 Oct. 1970	1260	1260-1380	1380-1490	1490-1605	1605
21 Oct. 1970-4 July 1972	1350	1350-1460	1460-1540	1540-1650	1650
			(M$/picul)		
4 July 1972-21 Sept. 1973	583	583-633	633-668	668-718	718
21 Sept. 1973-30 May 1974	635	635-675	675-720	720-760	760
30 May 1974-31 Jan. 1975	850	850-940	940-1010	1010-1050	1050
31 Jan. 1975-11 March 1976	900	900-980	980-1040	1040-1100	1100
11 March 1976	950	950-1000	1000-1050	1050-1100	1100

In the light of changes in exchange rates occasioned by the "floating" of the £ Sterling, the price range has been expressed in terms of the ex-works price of tin on the Penang market in Malaysian dollars per picul since 4 July 1972.

Tariffs

Canada

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
32900-1	Tin in ores and concentrates	free	free	free	free
33507-1	Tin oxides	free	15%	25%	free
33910-1	Collapsible tubes of tin or lead coated with tin	10%	17½%	30%	10%
34200-1	Phosphor tin	5%	7½%	10%	5%
34300-1	Tin in blocks, pigs, bars or granular form	free	free	free	free
34400-1	Tin strip waste and tin foil	free	free	free	free
38203-1	Sheet or strip, iron or steel, corrugated or not, coated with tin	10%	12½%	25%	8%
43220-1	Manufactures of tinplate	15%	17½%	30%	11½%

United States

Item No.		On or after January 1, 1975
601.48	Tin ore and black oxide of tin	free
608.91	Tinplate and tin-coated sheets, valued at not over 10¢ per pound	8%
608.92	Tinplate and tin-coated sheets, valued at over 10¢ per pound	0.8¢ per lb
622.02	Unwrought tin other than alloys of tin	free
622.04	Unwrought tin, alloys of tin	free
622.10	Tin waste and scrap	free
622.15	Tin plates, sheets and strips, not clad	6%
622.17	Tin plates, sheets and strips, clad	12%
622.20	Tin wire, not metal-coated or plated	6%
622.22	Tin wire, metal-coated or plated	6%
622.25	Tin bars, rods, angles, shapes and sections	6%
622.40	Tin pipes, tubes and blanks	6%
644.15	Tin foil	17.5%

Sources: For Canada, the Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa. For United States, Tariff Schedules of the United States Annotated (1976) TC Publications 749.

Titanium and Titanium Dioxide

MICHEL A. BOUCHER

Demand for titanium dioxide in 1975 was lower by some 20 per cent from that during the previous year. The markets for paint and coatings were responsible for most of the lower demand, since about 55 per cent of all TiO_2 produced is consumed by these markets. The demand for paper, which accounts for about 20 per cent of TiO_2 consumption, was also down in Canada and the United States. World production of ilmenite is estimated at 3.5 million tons*, in 1975 and world production of rutile is estimated at 338,000 tons.

Demand for TiO_2 is growing at about 5 per cent a year. With the world titanium dioxide capacity estimated at some 2 million tons a year, world capacity must continue to expand at a rate of 100,000 tons a year. Nevertheless, any expansion in titanium dioxide involves a number of difficulties. Titanium dioxide is produced by either the sulphate process or the chloride process, depending on the method of treating titanium-bearing ore. The sulphate process involves the dissolving of ilmenite or titania slag in sulphuric acid. In the process, ilmenite containing 30 to 50 per cent impurities is dissolved in 3 to 4 tons of sulphuric acid for one ton of the finished TiO_2 product. Used sulphuric acid is then discharged from the process in the form of waste sulphuric acid liquid and iron sulphate crystal.

An important feature of the chloride process is that the amount of waste materials discharged from the process is small, resulting in a saving in treatment costs. For some applications the whiteness of the finished product is superior to that of the sulphate-route process. Chlorine used for the reaction is recycled within the closed system of the process, with a make-up amount of about 0.2 tons chlorine for one ton of the finished TiO_2 product. The great disadvantage of the chlorine process is the limited availability of natural rutile ore. World reserves of rutile are far smaller than ilmenite. The chloride process requires highly advanced technology and equipment to ensure the stable operation of a large-scale plant. However, the development of substitute products for natural rutile is on its way and there are already three producers operating their ilmenite beneficiation plants using the chloride route. These are: Ishihara in Japan; Western Titanium N.L. in Australia and Dhrangadhra Chemical Works in India.

Generally speaking, where there is a growing concern for the environment a producer tends to choose the chloride route, notwithstanding the raw material and technological problems.

Canadian production and developments

Quebec Iron and Titanium Corporation (QIT) mines and processes ilmenite for the production of titania slag used in the manufacture of TiO_2 pigments by the sulphate process. Ilmenite is mined by open-pit methods in the Lac Tio — Lac Allard area of eastern Quebec and is crushed at the minesite to minus 3 inches. The crushed ilmenite is transported 27 miles by rail to the port of Havre-St. Pierre, where it is shipped up the St. Lawrence River to the company's beneficiation plant and smelter at Sorel, near Montreal. The crushed ilmenite is upgraded from about 86 per cent to some 93 per cent of combined titanium and iron oxides by means of heavy media separation, spirals and cyclones. The upgraded product is calcined in rotary kilns to lower the sulphur content, cooled, and mixed with powdered anthracite. Electric arc smelting of the calcine-coal mix yields titania slag and pig iron. Pigment-grade slag containing 70 to 72 per cent TiO_2 is in strong demand in world markets. It is marketed under the trade name *Sorelslag*. Pig iron is processed further to meet carbon and sulphur specifications for ductile iron manufacture. The product is also used as a substitute for scrap, and in powder metallurgy. It is marketed under the name *Sorelmetal*. *Sorelflux*, a carefully-sized raw ilmenite ore, is marketed as a steelmaking slag conditioner.

Because of the economic recession, demand for ilmenite ($FeO\text{-}TiO_2$) was weaker in 1975 than in 1974. Production of pigments from titania slag grading 72 per cent TiO_2 causes less pollution than production from ilmenite grading from 40 to 50 per cent TiO_2. This is a major reason why pigment producers prefer slag to ore and why demand for titania slag produced by Quebec Iron and Titanium Corporation (QIT) of Sorel, Quebec, remained strong.

* The short ton of 2,000 pounds is used throughout unless otherwise stated.

Table 1. Canada, titanium production and trade, 1974-75

	1974		1975p	
	(short tons)	($)	(short tons)	($)
Production (shipments)				
Titanium dioxide slag	..	51,930,882	..	55,075,000
Imports				
Titanium dioxide pure				
United States	2,503	1,600,000	2,024	1,675,000
United Kingdom	938	529,000	544	433,000
West Germany	976	715,000	132	117,000
Australia	—	—	19	6,000
Belgium-Luxembourg	57	47,000	—	—
France	1	1,000	—	—
Total	4,475	2,892,000	2,719	2,231,000
Titanium dioxide extended				
United Kingdom	217	130,000	125	119,000
United States	51	51,000	50	91,000
West Germany	6	6,000	68	44,000
Czechoslovakia	—	—	22	10,000
Switzerland	3	8,000	1	3,000
Total	277	195,000	266	267,000
Titanium metal				
United States	433	4,893,000	399	4,978,000
United Kingdom	15	410,000	40	1,118,000
Japan	8	37,000	5	58,000
Other countries	3	45,000	1	13,000
Total	459	5,385,000	445	6,167,000
Exports[1] to the United States				
Titanium metal, unwrought including waste and scrap	142	194,489	131[2]	215,165[2]
Titanium metal, wrought	76	714,623	170[2]	1,781,154[2]
Titanium dioxide	7,056	4,783,909	9,044[2]	5,920,514[2]

Source: Statistics Canada, except where noted.
[1]U.S. Department of Commerce, Imports for Consumption, Report F.T. 135; no identifiable classes are available for Canadian export statistics. [2]11 months 1975.
pPreliminary; — Nil; .. Not available

In 1975, QIT treated 1,796,200 long tons of ilmenite to produce 738,738 long tons of titania slag and 492,000 long tons of coproduct pig iron. QIT's production of slag in 1975 was 11 per cent lower than that of the previous year because of in-plant problems; sales, however, increased from $49 million to $59 million.

Most of QIT's titania slag is exported to the United Kingdom, west European countries, and the United States. Some 13 per cent of production is sold in Canada to the two pigment manufacturers. They are Canadian Titanium Pigments Limited (CTP), with plant at Varennes, and to Tioxide of Canada Limited (TCL), with plant at Tracy, both in Quebec. Both plants use the sulphate process.

Demand for titanium dioxide pigments was also lower in 1975. In addition, Canadian sales were affected by strikes in the domestic paper industry. The Canadian market for titanium dioxide pigment is about 70,000 tons a year, with the following approximate consumption mix: paint, 65 per cent; paper, 10 to 15 per cent; plastics, 5 to 10 per cent; and others, the balance.

CTP's production capacity was raised in 1975 from 37,000 tons to 40,000 tons a year, and TCL, through an expenditure of $600,000, raised its production capacity from 35,000 tons to 38,000 tons a year. Because most of the titanium pigment is consumed by the paint industry demand is seasonal, being strong in summer and weak in winter. The demand for pigments is also price inelastic, which means that producers reduce their output rather than cutting prices when consumption decreases.

Table 2. Canadian titanium production, trade and consumption, 1966-75

	Production			Imports		Consumption	
	Ilmenite[1]	Titanium Dioxide Slag[2]	Titanium Dioxide Pure	Titanium Dioxide Extended[3]	Total Titanium Dioxide Pigments	Titanium Dioxide Pigments[4]	Ferro-titanium[5]
				(short tons)			
1966	1,264,704	524,720	1,627	9,774	11,401	43,579	49
1967	1,442,204	602,448	1,616	9,763	11,379	43,447	54
1968	1,619,408	672,896	2,387	9,697	12,084	45,470	22
1969	1,824,144	749,280	2,504	8,651	11,155	47,418	34
1970	2,085,888	844,704	2,781	8,174	10,955	44,412	27
1971	2,087,008	852,992	5,942	5,725	11,667	45,990	21
1972	2,258,480	920,416	5,893	1,192	7,085	..	147
1973	2,295,216	942,704	4,744	419	5,163	..	15
1974	2,223,872	931,168	4,475	277	4,752	..	16
1975^p	1,701,423	826,564	2,719	266	2,985	..	..

Sources: Statistics Canada and company reports.
[1]Ore treated at Sorel from company reports; [2]Gross weight of 70-72 per cent TiO_2 slag produced, from company reports; [3]Approximately 35 per cent TiO_2; [4]Includes pure and extended TiO_2 pigments; [5]Ti content.
^{p}Preliminary; .. Not available.

Foreign developments

Union Corporation Limited, Industrial Development Corporation (IDC) of South Africa and Quebec Iron and Titanium (QIT) of Canada are jointly raising a $150 million Euromarket loan to help finance the Richards Bay heavy mineral sands project in South Africa. Total investment in the project has been estimated at almost $300 million, and includes the establishment of a mine, just north of Richards Bay, which will produce ilmenite, rutile and zircon, and a smelter at Richards Bay, which will convert ilmenite to a high TiO_2 slag (possibly 85% TiO_2) and to a low manganese pig iron by using the chloride process. Production rates are expected to be 450,000 tons a year of titania slag, 300,000 tons a year of ductile iron, 120,000 tons a year of zircon and 80,000 tons a year of rutile. Initial output is expected during 1978. The operating companies for the project will be Tisand (Pty.) Ltd. for the mine, and Richards Bay Iron and Titanium (Pty.) Ltd. for the smelter. Shareholdings in the project are IDC, 30 per cent; Union Corp., 30 per cent and QIT, 40 per cent.

Several other plans for ilmenite and rutile beneficiation plants or plant expansions in the world have been announced, and the major ones are: Western Titanium, Australia, with an expansion from 10,000 tons to 30,000 tons of TiO_2 a year; Ishihara Sangyo of Japan with an expansion from 27,000 tons to 48,000 tons a year; Kerr McGee Corporation, with a new 50,000 tons of TiO_2 a year at Mobile, Alabama, U.S.A.; Malaysian Trading with new production of 50,000 tons of rutile at Perak, Malaysia. Consolidated Gold Fields Australia Ltd. is proceeding on schedule with its Eneabba mineral sands mining project in Australia. Production is expected in the third quarter of 1976 at the rate of 250,000 tons a year of ore. This will result in the production of about 30,000 tons a year of rutile, 70,000 tons of zircon and about 150 tons of ilmenite. India's Metallurgical and Engineering Consultants is preparing a detailed feasibility study on a 48,000-ton-a-year titanium dioxide plant to be built in the state of Kerala by state-owned Kerala Minerals and Metals.

Table 3. Titania slag and iron production, Quebec Iron and Titanium Corporation, 1970-75

	Ore Treated	Titania Slag Produced	Iron Produced
		(long tons)	
1970	1,862,400	754,200	531,200
1971	1,863,400	761,600	535,300
1972	2,016,500	821,800	572,800
1973	2,049,300	841,700	579,000
1974	1,985,600	831,400	553,200
1975	1,796,200	738,004	492,000

Source: QIT.

Minerals and Canadian deposits

Titanium is the ninth most abundant element in the lithosphere, with an average content of approximately 0.50 per cent. It occurs predominantly in rocks of basic affiliations. Ilmenite ($Fe\ TiO_3$) and rutile (TiO_2) are usually the only two titanium minerals of economic significance. Ilmenite theoretically contains 52.66 per cent TiO_2 and 47.34 per cent iron oxide (FeO). It occurs extensively throughout rocks of igneous origin, but is only concentrated in economic deposits in gabbroic and anorthositic rock complexes where it occurs as massive lenses of ilmenite intergrown with hematite or magnetite. Ilmenite is also found as a heavy mineral constituent in beach or placer deposits which have been derived from igneous rocks by mechanical disintegration.

Rutile is essentially pure TiO_2 but in nature it may contain up to 10 per cent impurities, mainly iron and vanadium oxides. Rutile is a widespread accessory mineral in many types of igneous, metamorphic and sedimentary rocks, but is only of economic significance when it is concentrated in reworked beach or placer deposits in association with other heavy minerals, especially ilmenite and zircon, and, occasionally, cassiterite, columbite and tantalite.

Other titanium minerals such as brookite (TiO_2), anatase (TiO_2), perovskite ($Ca\ TiO_3$), sphene ($Ca\ TiSiO_5$) and leucoxene are often found in many ilmenite or rutile ore deposits, but rarely in sufficient concentrations to have any economic significance.

Commercial-grade ilmenite concentrates typically contain between 44 and 60 per cent TiO_2 and rutile concentrates normally average 95 per cent TiO_2.

The Canadian Shield, especially that part situated in the province of Quebec, contains many titaniferous deposits. Under existing technology and prevailing economics only the high-grade ilmenite-hematite or ilmenite-magnetite deposits attract much exploration activity but, ultimately, the largest potential may lie in the vast low-grade titaniferous magnetite deposits. These deposits have an average content of 20 per cent

Table 4. Salient titanium statistics, United States, 1974-75

	Ilmenite		Rutile		Titanium[1]	
	1974	1975[e]	1974	1975[e]	1974	1975[e]
	(short tons)					
Production	745,000	640,000	6,000	11,000	..	..
Imports	319,000[2]	450,000[2]	236,000[2]	216,000[2]	6,963	4,100
Consumption	1,109,000[2]	890,000[2]	292,000	230,000	26,896	17,500
Price/pound	..	..	..	..	$2.25	$2.75
Price/ton	$47[3]	$55[3]	$710[4]	$710[4]	..	..

Source: U.S. Bureau of Mines, Commodity Data Summaries, January 1976.
[1]Short tons sponge metal. [2]Includes titania slag from Canada. [3]54 per cent TiO_2, fob Atlantic seaboard, long ton. [4]fob Atlantic and Great Lakes ports, short ton.
[e]Estimated; .. Not available, or not applicable.

Table 5. Consumption of titanium concentrates in the United States, by products, 1974

	Ilmenite[1]		Titania Slag		Rutile	
Product	Gross Weight	Estimated TiO_2 Content	Gross Weight	Estimated TiO_2 Content	Gross Weight	Estimated TiO_2 Content
	(short tons)					
Pigments	839,284	492,206	257,125	182,257	241,003	228,507
Welding-rod coatings	(2)	(2)	—	—	11,759	11,181
Alloys and carbides	(2)	(2)	(3)	(3)	(2)	(2)
Miscellaneous[4]	12,693	9,070	—	—	39,899	38,032
TOTAL	851,977	501,276	257,125	182,257	292,661	277,720

Source: U.S. Bureau of Mines, Minerals Yearbook Preprint, 1974.
[1]Includes mixed product containing rutile, leucoxene and ilmenite. [2]Included with miscellaneous to avoid disclosing confidential data. [3]Included with pigments to avoid disclosure. [4]Includes ceramics, glass fibers and titanium metal.
— Nil

iron and 5 per cent titanium. Known reserves alone total many billions of tons. However, current production is restricted to one high-grade deposit in the Lac Tio – Lac Allard area of eastern Quebec. The ilmenite deposit is mined by open-pit methods, and constitutes one of the world's largest, with reserves exceeding 100 million tons grading 35 per cent TiO_2 and 40 per cent iron. In addition, the surrounding area has potential reserves of billions of tons of low-grade titaniferous magnetite disseminated throughout the gabbroic-anorthosite massif. The Lac Tio deposit occurs as a high-grade, sill-like structure in which the ilmenite forms intimate intergrowths with hematite. Another high-grade titanium deposit located at St. Urbain, 75 miles northeast of Quebec City could come into production in the near future, if titanium markets continue to exhibit their present strength. This deposit is a high-grade, massive dyke-like structure of ilmenite-hematite containing 20 million tons, grading 38 per cent TiO_2 and 40 per cent total iron.

The Alberta Energy Resources Conservation Board has made an estimate of the mineable Alberta oil sand reserves, and based on current technology the Board believes that some 66 x 10^9 tons of oil sand, with a solids content of roughly 56 x 10^9 tons, will be mined. Although there is some variation in heavy mineralization of the sands, it is believed that the in situ content of the sands is 0.21 per cent Ti and 0.05 per cent Zr. A single plant producing 125,000 bbl/day of synthetic crude oil would have the potential to produce 313,000 tons/yr of TiO_2 and 96,000 tons/yr of ZrO_2SiO_2 from mining 114 x 10^6 tons/yr of oil sand.

Table 6. Production of ilmenite concentrates by countries, 1973-75

	1973	1974	1975[e]
	(thousands of short tons)		
Canada[1]	943	931	800
Australia	793	909	890
Norway	830	935	725
United States	776	745	640
Finland	175	168	
Malaysia	204	210	
Sri Lanka	103	89	
India	85	85	450
Spain	4	–	
Brazil	5	5	
Japan	2	2	
Portugal	1	1	
TOTAL	3,921	4,080	3,505

Source: U.S. Bureau of Mines, *Minerals Yearbook Preprint 1974;* U.S. Bureau of Mines Commodity Data Summaries, January 1976; Statistics Canada.
[1]Titania slag containing 70-71 per cent TiO_2.
[e]Estimated.

Prices

During the year, the price of ilmenite remained at $55 a long ton; rutile, as reported by *Metals Week,* remained at about $700 a short ton; titania slag increased from $60 to $75 a long ton; U.S. sponge went from $2.25 to $2.70 a pound; U.S. billet, an important alloy of Ti-6A1-4V, rose from $3.91 to $4.86 a pound.

Table 7. Production of rutile concentrates by countries, 1973-75

	1973	1974	1975[e]
	(short tons)		
Australia	358,914	355,478	320,000
United States	9,255	6,266	11,000
India	3,748	3,800	
Sri Lanka	2,482	3,363	7,000
Brazil	46	210	
TOTAL	374,445	369,117	338,000

Source: U.S. Bureau of Mines, *Minerals Yearbook Preprint 1974;* Commodity Data Summaries, January 1976.
[e]Estimated

Prices in the United States published in Metals Week of December 29, 1975

	(U.S.$)
Titanium ore fob cars Atlantic ports, Great Lake ports	
Rutile, 96% per short ton delivered within 12 months	710.00
Ilmenite, 54% per long ton, shiploads	55.00
Slag, 70% per long ton, fob shipping point	75.00
Titanium metal, sponge, per lb fob mine or mill max.	
115 Brinell, 99.3%, 500 lb	2.70
Mill products, per lb delivered, 4,000-lb lots	
Billet, Ti – 6AL-4V (8" diameter random lengths)	4.86
Bar, Ti-6Al-4V (2" diameter)	7.48
Ferrotitanium, quoted in Engineering and Mining Journal	
Low carbon, per lb Ti delivered, 25-40% Ti	1.35
Titanium dioxide, Canadian prices, quoted in Canadian Chemical Processing, of titanium pigments, effective November 1975.	
Anatase, dry milled, bags, car lots, delivered, East, per 100 pounds	36.00

Table 8. United States, titanium metal data, 1970-74

	1970	1971	1972	1973	1974
	(short tons)				
Sponge metal					
Imports for consumption	5,931	2,802	3,808	5,172	6,963
Industry stocks	2,516	2,724	1,816	1,941	3,822
Government stocks (DPA inventories)	19,994	19,994	19,994	18,706	11.897
Consumption	16,414	12,145	13,068	20,173	26,896
Scrap metal consumption	7,242	6,149	7,802	10,038	10,599
Ingot[1]					
Production	24,331	18,387	20,267	28,932	36,132
Consumption	23,687	17,058	19,499	25,409	31,563
Net shipments of mill products[2]	14,480	11,241	12,627	14,530	17,443

Source: U.S. Bureau of Mines *Minerals Yearbook Preprint 1974.*
[1]Includes alloy constituents; [2]Bureau of the Census and Business and Defence Services Administration, Current Industrial Report Series BDCF-263.

Table 9. Typical rutile ore analysis

Element or Compound	Approximate Range (per cent by weight)	Element or Compound	Approximate Range (per cent by weight)
TiO_2	93.5 -98.5	ZrO_2	0.04- 1.0
CaO	0.02- 0.08	SiO_2	0.2 - 1.1
Iron (determined as		MgO	0.01- 0.2
FeO plus Fe_2O_3	0.3-1.0	Al_2O_3	0.05- 0.9
Nb_2O_5	0.10- 0.55	MnO	0.04- 0.2
V_2O_5	0.2 - 0.8	S	<0.01- 0.04
Cr_2O_3	0.1 - 0.4	P	<0.01- 0.02

Source: *Journal of Metals,* March 1975.

Table 10. Typical ilmenite ore analyses

Element or Compound	Approximate Range (per cent by weight) Australia	U.S.A.	India	Canada[1]
TiO_2	47-57	44-65	54-61	39
FeO	14-27	4-40	9-27	27
Fe_2O_3	11-26	1-26	14-25	24
MnO	0.5 -1.8	0.05-1.4	0.3 -0.4	0.14
MgO	0.2 -2	0.05-2.4	0.6 -1.0	3.2
Cr_2O_3	0.02-4	<0.01-0.3	0.05-0.25	0.11
P_2O_5	0.02-0.04	0.01-1.0	0.1 -0.3	0.06
V_2O_5	0.10-0.22	<0.01-0.20	0.1 -0.6	0.31
SiO_2	0.1 -1.5	0.3 -4.6	0.4 -1.4	6.0
CaO	0.02-0.2	0.05-1	0.05-0.2	1.0
Al_2O_3	0.5 -4	0.1 -3	0.9 -1.3	4.0
ZrO_2	<0.01-0.1	<0.01-0.6	0.5 -2.2	Nil

Note: Other sizeable ilmenite ore deposits are found in Europe (i.e., Norway, Portugal and the USSR), Asia (i.e., Malaysia), Brazil, and Africa (i.e. Sierra Leone, Republic of South Africa and Senegal).
Source: *Journal of Metals,* March 1975.
[1]Quebec Iron and Titanium Corporation is the sole producer of ilmenite ore in Canada.

Table 11. World titanium dioxide capacity and expansion plans ('000 tpa)

	Country	Sulphate Process cap.	Sulphate Process exp.	Chloride Process cap.	Chloride Process exp.	Total cap.	Total exp.
1.	**North & South America**						
	U.S.A.	399	—	341	158	740	158
	Canada	63	—	—	—	63	—
	Mexico	23	—	—	—	23	—
	Brazil	22	3	—	—	22	3
	Total	507	3	341	158	848	161
2.	**Western Europe**						
	U.K.	172	—	70	—	242	—
	West Germany	247	—	34	—	281	—
	Holland	34	—	—	—	34	—
	Belgium	65	—	—	—	65	—
	France	143	22	—	—	143	22
	Italy	81	38	—	—	81	38
	Finland	60	25	—	—	60	25
	Norway	20	—	—	—	20	—
	Spain	24	100	—	—	24	100
	Total	846	185	104	—	950	185
3.	**Eastern Europe**						
	Poland	—	36	—	—	—	36
	Czechoslovakia	20	—	—	—	20	—
	Yugoslavia	—	20	—	—	—	20
	USSR	80	—	—	—	80	—
	Total	100	56	—	—	100	56
4.	**Africa**						
	South Africa	21	—	—	—	21	—
5.	**Oceania**						
	Australia	45	—	—	—	45	—
6.	**Asia**						
	India	24	—	—	—	24	—
	Japan	198	12	—	30	198	42
	Korea	4	—	—	—	4	—
	Taiwan	3	17	—	—	3	17
	Total	229	29	—	30	229	59
	World Total	1,748	273	445	188	2,193	461

Source: Dr. Shigehi Tamads, Ishibara Sangzo Kaisha Ltd., Osaka, Japan — *Industrial Minerals,* January 1976.
—Nil.

Tariff profile (MFN — comparative ad valorem equivalents)

BTN	Description	United States	EEC	Japan	Canada	Cdn. Tariff No.
				(per cent)		
26.01	Titania ores & Conc.	Free	Free	Free	Free	32900-1
26.03	Titanium slag	Free	Free	Free (U.S. #603.62	Free	68105-1
28.25	Titanium oxides	7.5	9.6	7.5	12.5	92825-1
..	Ti whites & compounds	7.5	..	..	[illegible]	93207-6
73.02	Ferrotitanium	5.5	7.0	4.0	5.5	37506-1
81.04	Titanium					
	Unwrought	18.0	6.0	8.0	Free	34715-1
	Waste and scrap	18.0	6.0	Free	Free	
	Wrought	18.0	8.0	12.0	Free	34715-1

Source: Mineral Development Sector, Department of Energy, Mines and Resources, Ottawa.
.. Not available.

Tungsten

R.F. JOHNSON

In 1975, Canadian shipments of tungstic trioxide (WO_3) contained in scheelite concentrates were 2,987 000 pounds, compared with 3,557,600 pounds in 1974. Canada Tungsten Mining Corporation Limited continued to be Canada's only producer of tungsten concentrates. The lower production was a reflection of two factors; lower demand and lower-than-anticipated recovery rates for tungsten in Canada Tungsten's mill. Demand for intermediate products in Canada, while lower than in 1974, remained fairly strong during 1975.

The tungsten market was slow in 1975 principally as a result of reduced demand. Inventory reductions by consumers were also contributing factors. Prices remained fairly stable throughout 1975 following a sharp decline early in the year.

The world outlook for 1976 is somewhat brighter as a result of the mild economic recovery predicted for the year. Beyond 1976, the entry of three new producers into the market will, barring a period of exceptionally high demand, create an oversupply of tungsten in the short term.

Canada, production and trade

In 1975 Canadian shipments of tungstic trioxide (WO_3) contained in scheelite concentrates were 2,987 000 pounds, down from 3,557,600 pounds in 1974. Canada Tungsten Mining Corporation Limited is Canada's only producer of tungsten concentrates. The company's mine and mill are located at Tungsten in the Flat River valley of the Northwest Territories. In 1975 Canada Tungsten produced 162,892 short ton units* of tungstic trioxide (stu WO_3). For the first time in recent years, no byproduct copper was produced.

In September 1973, Canada Tungsten closed its open-pit operation, and it began production from a new underground mine in 1974. The underground mine, which unlike the open pit, is operated on a year-round basis, cost some $5 million to bring into production. On December 31, 1975, reserves contained in the new underground deposit were estimated to be 4,347,000 tons**, averaging 1.6 per cent WO_3 and 0.23 per cent copper. Initially, the underground ore was thought to have better milling characteristics than the open-pit ore and Canada Tungsten hoped that the effective capacity of the concentrator would be raised from 500 tons a day to 600 tons a day once ore from the underground mine was treated. However, some separation problems with a talc-like material in the ore have been encountered and recovery of WO_3 dropped to 63.78 per cent in the first quarter of 1975, when only underground ore was treated; from 80.20 per cent in 1973, when ore from the open pit only was treated. Canada Tungsten is currently investigating means of floating and discarding the talc-like material. In the interim, Canada Tungsten is mining a portion of the orebody that is low in this material.

Canada Tungsten produces two types of concentrate — a gravimetric and a flotation concentrate — at Tungsten. The gravimetric concentrate is ready for immediate sale, while the flotation concentrate requires further treatment. The flotation concentrate is shipped to Vancouver where it is washed with hydrochloric acid to remove calcite. Prior to washing, calcite comprises approximately one-half of the concentrate. The difficulties encountered with the talc-like material have principally affected recovery rates for the flotation concentrate.

Further problems with the flotation concentrate emerged when United States Customs declared that it was a leached product, because of the acid wash, and therefore, according to U.S. tariff classifications, could not be imported into the United States as concentrate but instead would have to enter under the tariff item covering tungsten chemicals. The tariffs for tungsten chemicals are much higher than those for concentrates. At a price of $90 a stu WO_3, the difference in the two

*A ton unit is 1 per cent of a ton, so a short ton unit (stu) represents 20 pounds. A concentrate containing x per cent WO_3 would contain x stu of WO_3 a ton.

**The short ton of 2,000 pounds is used throughout unless otherwise specified.

Table 1. Canada, tungsten production, imports and consumption, 1974-75

	1974		1975p	
	(pounds)	($)	(pounds)	($)
Production[1] (WO_3)	3,557,600	. .	2,987,000	. .
Imports				
Tungsten in ores and concentrates				
United States	—	—	2,100	7,000
Total	—	—	2,100	7,000
Ferrotungsten[2]				
United Kingdom	386,000	1,422,000	84,000	429,000
United States	24,000	122,000	16,000	85,000
Total	410,000	1,544,000	100,000	514,000
Metallic carbide tips or blanks				
United States		226,000		134,000
Sweden		18,000		90,000
Others		20,000		21,000
Metallic carbide inserts				
United States		1,033,000		1,087,000
Sweden		427,000		478,000
Others		1,026,000		688,000
Metallic Carbides nonagglomerated				
United States	1,270,300	5,036,000	986,900	3,229,000
Sweden	181,500	777,000	317,300	1,465,000
Others	44,200	187,000	14,500	58,000
Consumption (W content)				
Tungsten metal and metal powder	539,827	. .	. .	. .
Tungsten wire	29,265	. .	. .	. .
Others[3]	610,289	. .	. .	. .
Total	1,179,381	. .	. .	. .

Source: Statistics Canada.
[1]Producers' shipments; [2]Gross weight; [3]Includes tungsten ore, tungsten carbide.
pPreliminary; . . Not available; — Nil.

tariffs is over $8 a stu WO_3. This matter is being discussed with U.S. authorities.

Brunswick Tin Mines Limited, a subsidiary of the Sullivan Mining Group Ltd., completed metallurgical testing on ores from its Mount Pleasant property, about 40 miles north of St. Andrews in Charlotte County, New Brunswick. The orebody has a complex mineralogy, and ore reserves have been estimated at 30 million tons in the Fire Tower Zone and 12.6 million tons in the North Zone, averaging 0.2 per cent tungsten, 0.08 per cent molybdenum, 0.08 per cent bismuth, about 5 per cent fluorite, 1.0 ounce a ton indium and minor amounts of copper, lead, zinc and tin. At the end of 1973 a decline was started to give access to the Fire Tower Zone to obtain a bulk sample for metallurgical testing and to allow a better delineation of the deposit through underground drilling and sampling. A horizontal heading into the main orebody was completed early in 1975. Bulk samples were sent to the Department of Energy, Mines and Resources for testing. The tests investigated four possible flow sheets for the treatment of the ores. The samples contain a better than average tungsten content, about 0.3 to 0.4 per cent tungsten. Tungsten will be recovered as a concentrate, part of which, at least, will require leaching to remove associated minerals, and magnetic separation to produce a marketable product. The envisioned production is in the vicinity of 1,500 tons a day which would indicate a production of between 2 and 3 million pounds of tungsten a year. A production decision is expected within two years.

AMAX Exploration, Inc., a wholly-owned subsidiary of AMAX Inc., reported in 1973 that it had identified a scheelite deposit in the MacMillan pass area, about 240 miles northeast of Whitehorse on the Yukon-Northwest Territories boundary. AMAX outlined, by exploration and drilling, a deposit with erratic mineralization and wide variation in grade. More than

30 million tons averaging 0.9 per cent WO_3 have been indicated. In 1974, metallurgical and preliminary feasibility studies were conducted on the deposit. In 1975, studies on the environmental impact were completed. There has been no indication when development may commence.

Canadian consumption

Canadian consumption in 1974 of tungsten powders, ferrotungsten, tungsten chemicals, tungsten wire and tungsten scrap was about 1.4 million pounds and estimates indicate 1975 consumption declined about 5 to 10 per cent. There is no conversion of tungsten concentrates to these intermediate products in Canada. The minimum economical plant size for ammonium paratungstate, which is the base material from which most of the intermediate products are derived, is about 3 million pounds a year. Even if all Canadian demand were supplied from a domestic plant, 60 per cent of the production would have to be exported; the primary market being the United States. Because of the high tariff structure prevailing in the United States, any Canadian producer is effectively barred from competing in that market. There is only one producer of intermediate products in Canada, Macro Division of Kennametal Inc. which produces tungsten powders from scrap. In recent years, a number of companies have at some time produced ferrotungsten; however, this has been on a sporadic basis and a ferrotungsten industry *per se* seems to be an unviable proposition in Canada.

The major consumers of intermediate tungsten products in Canada and the principal products consumed are:

A.C. Wickman Limited (c)
Kennametal of Canada, Limited (c)
Kennametal Tools Ltd. (c)
Sandvik Canadian Limited (c)
Valenite-Modco Limited (c)
Macro Division of Kennametal Inc. (m,s)
Atlas Steels Company Limited (f)
Deloro Stellite Division of Canadian Oxygen Limited (m)
Dominion Colour Corporation Limited (p)
GTE Sylvania Canada Limited (w)
Canadian General Electric Company Limited (c,w)
V.R./Wesson Limited (c)
Firth Sterling (Canada) Limited (c)
Westinghouse Canada Limited (w)

c, carbide powders; m, metal powder; s, scrap;

f, ferrotungsten; w, wire; p, tungsten chemicals.

World developments

World production in 1975 was an estimated 81 million pounds of tungsten in concentrate, a decline of approximately 1.7 per cent from the previous year. Mine production is approximately divided equally between communist and noncommunist countries. In recent years consumption has exceeded production, with the difference being supplied by the General Services Administration (GSA) stockpile in the United States. Releases from the GSA stockpile in 1975 were approximately 4.2 million pounds of tungsten contained in concentrate, 0.5 million pounds less than the previous year.

The year 1975 was a quiet one for tungsten; no new producers began production nor were there any closures among existing producers. One small producer, the Brandberg West tin-tungsten mine in South-west Africa, did reopen in 1975.

Four new producers of tungsten concentrate are scheduled to commence production in 1976 and 1977. In Turkey, Etibank, the state-owned mining company, will bring a new tungsten mine into production in 1976 at Bursa. Production will be about 3,000 tons a year of concentrate, averaging 65 per cent WO_3. Reserves are estimated to be 13.5 million tons, grading 0.5 per cent WO_3. The mine was initially to be in production by April 1975, but a fire in the concentrator delayed the start-up until 1976. In the United States, Union Carbide Corporation plans to open a new tungsten mine near Alamo, Nevada, in late 1976. Although grade and reserves have not been announced, production will probably be in the range of 2,000 tons a year of WO_3, and mine life in the vicinity of 20 years. The ore will likely be processed at Union Carbide's Pine Creek, California treatment plant. A small project in Brazil will produce about 90 tons a year of 70 to 75 per cent WO_3 concentrate from mine tailings commencing in early 1976. The new company, Brejui Mineracao e

Table 2. Canada, tungsten production, trade and consumption, 1966-75

	Production[1] WO_3 Content	Imports		Consumption Tungsten Content
		Tungsten Ore[2]	Ferro-Tungsten[3]	
	(pounds)			
1966	4,263,927	523,600	192,000	941,207
1967	267,600	233,600	192,000	891,411
1968	3,584,920	131,700	118,000	1,181,541
1969	4,063,488	426,500	210,000	1,050,824
1970	3,726,800	182,200	200,000	984,777
1971	4,624,208	153,300	222,000	639,765
1972	4,447,316	239,900	254,000	1,176,564
1973	4,640,400	12,000	172,000	1,019,706
1974	3,557,600	—	410,000	1,179,381
1975^p	2,987,000	2,100	100,000	. .

Source: Statistics Canada.
[1]Producer's shipments of scheelite (WO_3 content); [2]Content; [3]Gross weight.
^{p}Preliminary; — Nil; . . Not available.

Metalurgia SA, will be 51 per cent owned by Brazilian interests and 49 per cent by Japanese interests. In 1977, Wolfram GmbH, a joint venture of Metallgesellschaft A.G. and Vereinigte Oesterreichische Eisen und Stahlwerke (Voest), will begin production at a new mine near Mittersill in Austria. The production will be converted to either tungsten metal powder or tungsten carbide powder. Production will be in the order of 1,000 tons a year of tungsten contained in tungsten metal or carbide powder. Ore reserves are currently estimated to be 2.5 million tons grading 0.6 to 0.7 per cent WO_3. These four projects will be capable of producing approximately 3,500 tons of tungsten contained in concentrate.

Intubol, a new Bolivian tungsten firm, will build a $4.5 million tungsten complex at Viacha which, upon completion in 1978, will have the capacity to produce 2,000 tons a year of ammonium paratungstate and 1,000 tons a year of tungsten powders. A state-owned company, ENAP, holds 51 per cent of Intubol stock with an option to increase its share to 66 per cent. The remaining stock is held by private interests in Bolivia.

As part of the United States' program to extend tariff preferences to Less Developed Countries (LDCs), a special preference has been given on the tariff item which covers the importation of ammonium paratungstate. The special preference is a zero tariff rate, as opposed to the 21 cent per pound contained tungsten plus 10 per cent ad valorem rate that is still effective against Canada, subject to compliance with the general conditions that the imports from LDCs cannot supply more than one-half of the market for that product in the United States and that the total level of imports from LDCs not exceed $25 million. This has probably provided the incentive for some countries, such as Bolivia, to review the possibility of producing APT for export to the United States. The General Services Administration (GSA) continued to sell tungsten on a sealed-bid basis. The maximum offering during 1975 was set at 500,000 pounds a month, with 75 per cent allocated for the U.S. market and the remaining 25 per cent for export markets. In 1975, sales from the stockpile amounted to some 4.2 million pounds. At year-end, the GSA held some 116 million pounds of tungsten of which only 4.2 million pounds is not available for release.

Tungsten concentrate production in Thailand continued to decline in 1975. While part of this decline resulted from market conditions, some of the decline was attributable to the gradual exhaustion of shallow ore reserves on the Khao Soon field in southern Thailand. The Khao Soon field, which may be the world's largest single wolframite deposit, was discovered in 1970 by Siamerican Mining, which is 63 per cent owned by Thai interests, 32 per cent by American interests and 5 per cent by British interests and is wholly Thai-managed. Following the announcement of the discovery, thousands of miners began working the area despite government mining laws to the contrary. Most of the initial work was done by pick and shovel; however, more recently some of these illegal operations have become more sophisticated in their mining methods as the readily accessible surface showings have been worked out. This initial rush has been accompanied by gang wars, protection rackets and black market operations for both the sales of tungsten concentrate and of supplies to the miners. The long-term impact of this initial exploitation on future production rates and the future level of mineable reserves is unknown; however, until law and order are restored in the area, and until a national development program can be implemented, production rates can be expected to continue their decline.

Warman International Ltd., a Peko-Wallsend Ltd. subsidiary, continued to be the major Australian producer of tungsten from its mine on King Island.

Table 3. Tungsten production in ores and concentrates, 1973-75

	1973	1974	1975
	(thousands of pounds of contained tungsten)		
Europe	22,582^e	22,663^e	24,000^e
France	1,532	1,307	1,911
Portugal	3,311	3,258	3,234
Spain	688	765	732
U.S.S.R.	16,314^e	16,755^e	17,000^e
North America	11,762^e	11,678^e	8,530^e
Canada	3,680	2,811	2,370
United States	7,059	7,835	5,500
Mexico	674	681	660^e
South America	8,827	8,391	8,300^e
Bolivia	4,575	4,506	4,750^e
Brazil	2,319	2,189	1,800^e
Peru	1,752	1,504	1,300^e
Africa	1,722^e	1,426^e	1,400^e
Asia	35,605^e	35,942^e	35,400^e
People's Republic of China	17,637^e	18,739^e	18,000^e
Democratic People's Republic of Korea	4,751^e	4,751^e	4,700^e
Japan	1,832	1,695	2,013
Republic of Korea	4,222	4,806	5,584
Thailand	5,736	4,859	3,909
Oceania	2,734	2,361	3,390^e
Australia	2,732	2,352	3,380
Total	82,232^e	82,461^e	81,020^e

Source: Tungsten Statistics January 1976, UNCTAD Committee on Tungsten and estimates by Mineral Development Sector, Department of Energy, Mines and Resources, Ottawa.
^{e}Estimated.

Warman completed development of the Bold Head and Dolphin orebodies in 1975 and discontinued its surface operations. Most of the ore treated in the mill came from the underground operations, although some stockpiled ore from the surface operations was used to supplement mill feed early in the year. Reserves in the Bold Head and Dolphin orebodies are estimated to be 7 million tons averaging 0.80 per cent WO_3.

The new five-year plan for the U.S.S.R. calls for, among other things, a significant increase in metal production. Particular emphasis is to be given to increasing the production of lead, zinc, copper, molybdenum, tungsten and gold. Domestic production of tungsten is currently not sufficient to meet the U.S.S.R.'s consumption of tungsten. Approximately one-third of the U.S.S.R.'s requirements are imported, principally from the People's Republic of China. The concentrating plant at the Lultun complex in the Magadan Oblast began processing tungsten ore in October of 1975. The Lulsur open-pit and the first section of the Dzhicla tungsten-molybdenum complex in Buryat A.S.S.R., both increased their production rates in 1975. The increase in tungsten production, caused by these developments, is unknown. In the longer run, it does not appear that the U.S.S.R. will become self-sufficient and, in fact, its dependence on imports will likely increase.

In Argentina, the Mining Sub-secretariat has made a promotional grant of 8 million pesos for the construction of a regional tungsten concentrator in the province of San Luis. The grant is part of a larger effort to rationalize and integrate some parts of the mining industry in Argentina. In 1975, the Sangdong mine of the Korea Tungsten Mining Co. Ltd. produced an estimated 600 tons of APT and 350 tons of tungsten powders from its recently installed facilities of Taegue. Exploration for tungsten continued in several countries in 1975, notably Portugal, France and Burma. None of these countries announced any results of their exploration programs.

Uses

From the viewpoint of consumption, the high price of tungsten ore, its relative shortage, variable supply and concern over world reserves have created a situation in which the general response of consumers has been to minimize tungsten usage where possible. Substitutions or partial substitutions have limited tungsten markets in the past and probably will restrict the growth of tungsten markets, at least in the near-future. The principal uses of tungsten are in tungsten carbides, tungsten-bearing steels, nonferrous alloys, tungsten mill products and tungsten chemicals.

Tungsten carbide (WC) is one of the hardest materials known. It is produced by chemical combination of tungsten metal powder and finely divided carbon. Cobalt is added as a binder and the material is then compacted to the desired form and sintered to produce the cemented tungsten carbides. The largest end use of cemented tungsten carbides is in cutting tools which includes both mechanically-held and brazed-in-place inserts. Cutting tools are used in machining steel, cast iron and nonferrous metals and in the woodworking and plastics industries as shaping tools. Tantalum, titanium and columbium carbides are frequently added to tungsten carbide-cobalt mixtures to lower the coefficient of friction of the cemented carbides and, thereby, produce grades better suited to the machining of specific products, particularly steel. In the more abrasive applications such as dies for wire and tube drawing, punches and dies for metal forming, bits and tools for drilling equipment and wear-resistant parts, a straight tungsten carbide-cobalt mixture is used almost exclusively. Other uses of tungsten carbide are in tire studs, studs in spikes for golf shoes, and armour-piercing projectiles.

Titanium carbide has been produced commercially in recent years, but on its own, it has not found wide applications. Titanium carbide compositions are extremely brittle and under current technology it seems unlikely that titanium carbide will replace tungsten carbide to a major extent. However, the coating of tungsten carbide tools with 0.0002 inch of titanium carbide enhances their life in machining steel. This development may moderate the increased demand for tungsten carbide cutting tools. Ceramics may be substituted for tungsten carbides in applications involving machining with high speeds and light cuts, but ceramics usually lack sufficient toughness and wear-resistance, despite their greater hardness in the more-abrasive applications.

Tungsten carbides should retain the market for abrasive applications, i.e., wear-resistant and drilling applications. There will probably be a trend to the use of increasing amounts of mixed carbides for cutting tools, coating of tungsten carbide cutting tools to extend their life and substitution of tungsten carbide in the less-abrasive applications by the cheaper ceramics and titanium carbide.

Tungsten is added to steels either as ferrotungsten (80 per cent W), melting base (30 to 35 per cent W), scheelite ($CaWO_4$) or as tungsten-bearing scrap. The principal tungsten-bearing steels are tool steels. These steels are used in some of the applications of the carbides, but usually in the applications where lower operating temperatures are encountered. Some tungsten is also consumed in certain stainless steels that are used in elevated temperature environments. In addition, tungsten was used in some magnet and die steels that have largely been supplanted by other products.

Tungsten usage in the steel industry has stagnated or declined in most countries because of the availability of lower-cost substitutes. Molybdenum-tungsten tool steels have to a large extent supplanted tungsten tool steels. Molybdenum, while it imparts slightly inferior properties to the steel compared with tungsten, is a lower-cost addition and because of this and its greater availability, molybdenum has been substituted for substantial portions of the tungsten in tool steels. Also, there are competitive stainless steels for the tungsten-bearing stainless steels and the applications will largely determine which are used. At this time, it is probable that the maximum substitution of tungsten has occurred and that tungsten usage will again commence growth in the steel industry, but significant growth will only occur if the price and availability of tungsten are comparable with those of molybdenum.

The most important tungsten-containing alloys are superalloys. The tungsten is added usually in the form of tungsten metal powder, although tungsten scrap can be used to satisfy part of the tungsten requirements. Superalloys, which are used in applications where high strength is required at high temperatures, can be classified into three principal types; nickel base, iron base and cobalt base. At present, the principal usage of tungsten is in the cobalt-base or "Stellite" superalloys. The nickel- and iron-base superalloys currently contain little or no tungsten; however, several companies are developing new alloys that contain several percentages of tungsten and should substantially increase the use of tungsten in the nickel- and iron-base superalloys. The expected rapid growth in usage of superalloys, combined with a greater usage of tungsten in superalloys, should make this an important growth market for tungsten.

The most important properties of tungsten in its metallic form are its high melting point, low vapour pressure, high hardness, good electrical conductivity and low coefficient of thermal expansion. Tungsten mill products are made by compressing the tungsten metal powder into the desired shape and then sintering the compressed shape to produce a uniform product. The principal tungsten products produced are rods, wire and flat products.

Discs cut from tungsten rods are used as electrical contacts. In this application tungsten furnishes improved resistance to heat deformation where sparking and high temperatures occur at electrical contact points. Pure tungsten contacts have found their principal use in ignition circuits of automobiles and aircraft; however, the trend to electronic ignition systems will decrease the use of tungsten in this application. Tungsten discs are also used as heat sinks in semiconductor applications. Tungsten is also used in combination with other elements in electrical contacts and breakers for industrial applications.

Tungsten wire is used for the filaments in incandescent lamps and for heating elements in fluorescent lamps and vacuum tubes. The use of vacuum tubes is declining, but tungsten usage overall should continue to grow as demand for the different types of lamps grow. The use of tungsten wire in automobile windshields for deicing and defogging is a minor new application.

Flat products are used in fabricating parts for electron tubes and radiation shields and in parts for very high-temperature applications in reducing or inert atmospheres.

Among other uses of metallic tungsten, the most important is in heavy metals. Heavy metals are used in areas where counterweights or high-density material are required in limited spaces, e.g., in self-winding watches and in aircraft. Tungsten usage in heavy metals will grow at a slow rate because of the increasing availability and lower cost of depleted uranium, which has only a slightly lower density than tungsten. Steel tubes filled with tungsten carbide powder are used as electrodes in a welding method known as the Tungsten Inert Gas (TIG) method.

Tungsten compounds are used in small volume throughout the chemical industry. The principal end use is as sodium tungstate, phospotungstic acid and phospotungstomolybdic acid in dyes, toners, phosphors, chemical reagents and corrosion inhibitors. A minor and unpredictable use is as petrochemical and chemical catalysts.

Prices

According to the *London Metal Bulletin,* the monthly price for tungsten concentrate reached a peak of $92.48 a stu WO_3 in February 1975. The price dropped sharply in June to $81.79 a stu WO_3, where it remained relatively stable, ending the year at $78.78 a stu WO_3. The *London Metal Bulletin* price is quoted in pounds sterling. Because of Britain's economic difficulties and the resultant doubts over the pound's stability, contracts were increasing quoted and transactions conducted in U.S. dollars. This trend is expected to continue for the next several years at least.

Price stabilization

From January 19 to 23, 1976, a meeting of the Working Group of the UNCTAD Committee on Tungsten was convened to discuss alternative proposals for the stabilization of tungsten prices. The terms of reference for the Tenth Session of the Working Group on Tungsten included the following:

> "Identify and evaluate the practical, economic and technical aspects of proposals which could be incorporated in an intergovernment producer/consumer arrangement with special emphasis on the feasibility of proposals based on a system of minimum and maximum prices for the commodity; and proposals which would provide a system of exchange of necessary and timely data for the purpose of improving understanding of the market and greater stability of prices. In considering a system of minimum and maximum prices, the Working Group should give particular attention to and make recommendations, as appropriate, on:
> i) definition of the base product(s);
> ii) appropriate price indicator;
> iii) appropriate mechanisms to defend minimum and maximum prices;

iv) any other factors relevant to the successful operation of a system of maximum and minimum prices."

The terms of reference had been agreed upon at the Ninth Session of the UNCTAD Committee on Tungsten held at Geneva from July 28 to August 2, 1975, when a group of producer countries, led by Bolivia, advocated an international agreement to stabilize tungsten prices.

At both the Ninth Session and the Working Group meeting, distinct philosophical divisions emerged. Most exporting countries pressed for the almost immediate preparation of a draft tungsten agreement. This was opposed by consuming nations and some producing nations as being a too-rapid and radical first step. Several consuming nations appear to be opposed to any type of price stabilization agreement at all, while others expressed a willingness to consider price stabilization proposals but were not prepared to move at the speed which most exporting countries desired. Given these attitudes, there appears to be little opportunity for arriving at a general consensus as to either the development or implementation of any price stabilization agreement. Indeed, at the Working Group meeting, the recommendation was simply to instruct the UNCTAD Secretariat to prepare a document setting forth the major alternatives for a stabilization agreement for tungsten. This was, however, a compromise resolution and no general agreement was reached on the terms of reference. The recommendation was a stop-gap measure and essentially deferred any decision, one way or the other, until late in 1976.

Outlook

The demand picture for 1976 is somewhat brighter than it was in 1975. The mild economic recovery predicted for 1976, plus the fact that no major inventory reductions by consumers are expected to occur during the year, will lead to an increase in demand. However, with the slow economic recovery foreseen, the short-term outlook is not good. The additional production from the mines expected to open in 1976-77 will probably create an oversupply of tungsten.

The longer-term outlook is unknown since it will depend largely on the action or inaction of the UNCTAD Committee on Tungsten and the Primary Tungsten Association. Actions by either group will undoubtedly affect price, and through it, consumption and production. Until such time as these situations become clarified, what the future holds is largely unknown.

Tungsten prices according to Metals Week for December 1974 and 1975.

	1974	1975
	(U.S. $)	
Tungsten ore, 65% minimum WO_3, per stu of WO_3		
	effective Dec. 2, 1974	effective Dec. 1, 1975
G.S.A. Domestic, duty excluded	88.265	77.965
G.S.A. Export, duty excluded	82.149	77.169
	effective Dec. 12, 1974	effective Dec. 11, 1975
L.M.B. ore quoted by London Metal Bulletin, cif	81.588-85.772	77.023-80.691
	effective Nov. 8, 1974	effective Apr. 4, 1975
Ferrotungsten, per pound W, fob shipping point, low-molybdenum	. .	7.750
Tungsten metal, per pound, cif U.S. ports		
Carbon red, 98.8%, 1,000 pound lots	. .	. .
	effective June 17, 1974	effective Aug. 8, 1975
Hydrogen red, depending on Fisher No. range	9.640-11.340	10.210-12.010

. . Not available.

Tariffs

Canada

Item No.		British Preferential	Most Favoured Nation	General	General Preferential
32900-1	Tungsten ores and concentrates	free	free	free	free
34700-1	Tungsten metal in lumps, powder, ingots, blocks or bars and scrap of tungsten alloy metal	free	free	free	free
34710-1	Tungsten rod and tungsten wire	free	free	25%	free
35120-1	Tungsten alloys in powder, pellets, scrap, ingots, sheets, strip, plates, bars, rods, tubing, wire (expires October 31, 1975)	free	free	25%	free
37506-1	Ferrotungsten	free	5%	5%	free
37520-1	Tungsten oxide in powder, lumps, briquettes	free	free	5%	free
82900-1	Tungsten carbide in metal tubes	free	free	free	free

United States

Item No.		
422.40	Tungsten carbide, on W content	21¢ per lb + 12.5%
422.42	Other tungsten compounds, on W content	21¢ per lb + 10%
601.54	Tungsten ore, on W content	25¢ per lb
607.65	Ferrotungsten, on W content	21¢ per lb + 6%
629.25	Tungsten metal waste and scrap, not over 50% tungsten, on W content	21¢ per lb + 6%
629.26	Tungsten metal waste and scrap, over 50% tungsten, on W content	10.5%
629.28	Tungsten metal, unwrought, other than alloys: lumps, grains, powders, on W content	21¢ per lb + 12.5%
629.29	Tungsten metal, unwrought, other than alloys: ingots and shot	10.5%
629.30	Other unwrought tungsten metal	12.5%
629.32	Unwrought tungsten alloys, not over 50% tungsten, on W content	21¢ per lb + 6%
629.33	Unwrought tungsten alloys, over 50% tungsten	12.5%
629.35	Wrought tungsten metal	12.5%

Sources: For Canada, the Customs and Tariff Amendments, Department of National Revenue, Customs and Excise Division, Ottawa. For United States, Tariff Schedules of the United States Annotated (1976) T.C. Publication 749.

Uranium

R.M. WILLIAMS

Evidence of expanding markets, improved prices and the short supply of uranium became abundantly clear in 1975, providing the much-needed impetus for widespread activity in all phases of uranium operations. Exploration activity, that had been at low levels in recent years in Canada, was evident in most provinces as well as the Northwest Territories, and all producers were in the process of expanding their uranium-producing facilities. In addition, one new company was readying its new mine and mill for production, a second was reopening a past producer and another was planning for production, possibly as early as 1978. Indicative of the improved market, Canada's Atomic Energy Control Board (AECB) by year-end had announced authorized exports of some 74,000 tons* of U_3O_8; all since September 1974 when the federal government announced its new uranium export guidelines.

The most significant international development has been the turn-around in uranium prices which has resulted in higher levels of uranium exploration activity, hampered for the most part only by limitations in equipment and personnel. Demand for uranium continued strong and by year-end very little was available for immediate delivery. World production, which had been in the order of 25,000 tons of U_3O_8 annually, remained unchanged in 1975, but is expected to increase, beginning in 1976, primarily due to developments in Africa, Canada and the United States.

Production and development

Although Canadian uranium shipments totalled 6,126 tons of U_3O_8 in 1975, production was only slightly higher than last year, at some 4,565 tons U_3O_8. Over 80 per cent of this output came from Denison Mines Limited and Rio Algom Limited** at Elliot Lake, Ontario. The remainder came from two operations in northern Saskatchewan, that of Eldorado Nuclear Limited, near Uranium City and Gulf Minerals Canada Limited at Rabbit Lake, 200 miles southeast of Uranium City. The latter operation, the first new uranium producer in Canada since the late 1950s, began production late in the year.

Production was lower than had been expected in 1975 due largely to the lack of sufficient miners and companies' planned programs to mine lower-grade ores in order to maximize ultimate recovery of their deposits, the latter being made possible by the recent rise in uranium prices. The manpower problem was particularly distressing and all producing companies had instituted training programs in order to help alleviate the miner shortage. Moreover, the three established companies were in the midst of major house-building programs to improve and add home or apartment units to accommodate the required increase in workers. Gulf's staff-shuttling plan was proving very successful and was being examined by prospective new producers as a method of operating remotely-located mining ventures.

Denison's mill treated a total of 1,339,969 tons of ore during the year, with an average grade of 2.30 pounds U_3O_8 a ton, to produce 2,911,000 pounds U_3O_8. Production and development was again concentrated in the eastern portion of the Denison orebody, and some pillar recovery was carried out in the northeast. The major program during 1975 was the completion by year-end of the mill expansion to a capacity of 7,100 tons a day. In addition, the Roman Island and Knowles Island air raises were completed, increasing mine ventilation capacity to 1.4 million cfm. Programs to expand hoisting capacity to some 10,000 tons a day will continue throughout 1976. Toward this end, several modifications are being made to the main mine, including the installation of two new belt conveyors for transporting additional ore to the underground crusher (expected to be completed by mid-1976) and an additional high-horsepower motor to increase the speed of the hoists. Long-range plans see

* Short tons used throughout except where noted; 1 short ton U_3O_8 = 769.3 kgms uranium metal.

** Formerly Rio Algom Mines Limited; change effective April 30, 1975 the development of the now inoperative Stanrock and Canmet Mines which adjoin Denison to the east. With this in mind, and also to provide additional airways to surface, the company continued to drive two exploration headings from its main mine to Stanrock. This project is expected to be completed in 1977.

Rio Algom's Quirke mill on the north limb of the Quirke syncline operated at an average of 4,350 tons of ore a day, treating 1,466,000 tons of ore, with an average recovered grade of 3.10 pounds U_3O_8 a ton, to produce 4,639,000 pounds of U_3O_8; average mill recovery was 95.1 per cent. A total of 5,592,000 tons of U_3O_8 was actually delivered under various domestic and export contracts. The company continued with its program of expanding its Quirke mill from 4,500 to 7,000 tons a day, with completion expected in 1978. Also of importance was the completion of a decline at the New Quirke mine, which will permit the development of three new levels to provide increased mill feed. Installation of conveyors and a new underground crusher will be completed by mid-1976.

Table 1. Uranium production in Canada, by provinces, 1974-1975

	1974		1975^p	
	(pounds)	($)	(pounds)	($)
Production (U_3O_8 shipments)				
Ontario	8,442,966	. .	10,569,000	. .
Saskatchewan	1,147,545	. .	1,682,000	. .
Total	9,590,511	. .	12,251,000	. .

Source: Statistics Canada.
. . Not available for publication; ^{p} Preliminary.

On the south limb of the Quirke syncline, Rio Algom was dewatering the Milliken and Lacnor mines and extracting uranium values from the water, using a portion of the previously-inactive Milliken mill. To increase hoisting capacities, one of the two shafts at each of Milliken and Lacnor will be slashed to 25 feet in diameter. Although no decision has yet been made as to location or make-up of the milling complex on the south limb, the juxtaposition of the three properties and the continuity of the orebody will allow a high degree of flexibility as to where the mill can be located. The company's long-range plans foresee the production of some 20,000 tons of ore a day from its Elliot Lake operations by the middle of the next decade.

Eldorado continued to operate its mill at considerably less than full capacity. A total of 150,000 tons of ore were mined to produce 855,000 pounds of U_3O_8. Some 90 per cent of the mill feed came from the main Fay mine while the remainder came from the Eagle deposit, a small low-grade, open-pit operation about two miles northeast of the Eldorado mill. There are three other surface deposits in the immediate area which have been developed and which can be used to maintain an increased milling rate as the company proceeds with the development of the lower Fay orebodies and the rehabilitation of the shut-down Verna mine east of the Fay. Full production from the Verna is scheduled for 1977. Importantly, Eldorado's exploration has indicated a new underground uranium deposit to the east that can be reached from the Verna openings. To handle the planned increase in tonnage, probably in the 1,800-ton-a-day range, additional crushing, grinding and leaching facilities will be added to the mill. Eldorado plans to complete its total expansion program to a capacity of 1,000 tons of U_3O_8 a year by 1979. Some $50 million will be spent over the 1976-80 period, of which about 30 per cent will be for housing and other forms of community infrastructure.

By the end of 1975 the Rabbit Lake open-pit operation of Gulf Minerals Canada Limited and Uranerz Canada Limited had been prepared for production. The mill, which has a rated production capacity of 2,250 tons of U_3O_8 annually, was undergoing tune-up operations at year-end. A unique aspect of the Rabbit Lake operation is the commuter service that has been used to obviate the need for a townsite. Employees work an extended seven-day work week and are then flown to either Saskatoon, Prince Alberta, La Ronge, Uranium City, Stony Rapids or Black Lake for one week off.

Near Bancroft, Ontario, Madawaska Mines Limited (51 per cent Federal Resources Corp. and 49 per cent Consolidated Canadian Faraday Limited) was, at year-end, in the process of reopening the Faraday mine. Plans call for a resumption of production by about mid-1976. The mine will require a new production hoist and new crushing and grinding equipment because the original equipment was sold when the mine closed in 1964. The mill will have a capacity of 1,500 tons of ore a day.

At Agnew Lake, 30 miles west of Sudbury, Ontario, Agnew Lake Mines Limited continued its experimental *in situ* mining-leaching program, announced in 1974. The surface tests on broken ore were successful, and the company moved underground to build up a supply of broken ore in the test stopes. The necessary pipe transport and spray system was largely installed and towards the end of the year, the company was in the process of building up the bacterially-produced leaching solution necessary to commence the pilot plant in 1976. On December 31, 1974 Agnew Lake sold an undivided 10 per cent interest in the project to Uranerz Exploration and Mining Limited for $4.8 million. The agreement provides for the formation of a joint venture whereby the partners will contribute to all expenditures and share in any future production on a pro rata basis.

In the Carswell Dome area of northern Saskatchewan, Amok Limited continued development work on its Cluff Lake deposits. Final feasibility studies were being completed at year-end and mill design was under way. It was envisaged that the deposits will be exploited in several phases, beginning with the high-grade D orebody and a small mill capable of treating some 200 tons of ore a day. Under this scheme, production from the D orebody would last about three years, during which time the mill would be expanded to treat the lower grade ore from the Claude, and later from the N, zones. Mining will be by open pit and the annual output is expected to be about 2,000 tons of U_3O_8 a year.

Although initial production from Amok's Cluff Lake operation had been expected by 1978, final decisions had not been made pending implementation of the Saskatchewan government's revised uranium royalty system. In November, Saskatchewan authorities proposed a new two-royalty system; a basic 5 per cent royalty on the gross value of production, and an additional royalty which would increase, depending upon the "ratio" of operating profit to capital investment for the uranium project. This additional proposed royalty was reported to be zero if the "ratio" were less than 10 per cent, increasing to a maximum of 55 per cent if the "ratio" exceeds 25 per cent. Discussions were under way at year-end between the Saskatchewan government and several companies whose development and production expansion plans will be affected by the new royalties.

Canadian exploration activity

In response to increased uranium prices and a ready market, the level of uranium exploration activity in Canada continued to rise throughout 1975. This activity was evident in virtually every province and territory, much of it linked in some way to foreign consumers, anxious to assure their longer-term nuclear fuel supplies.

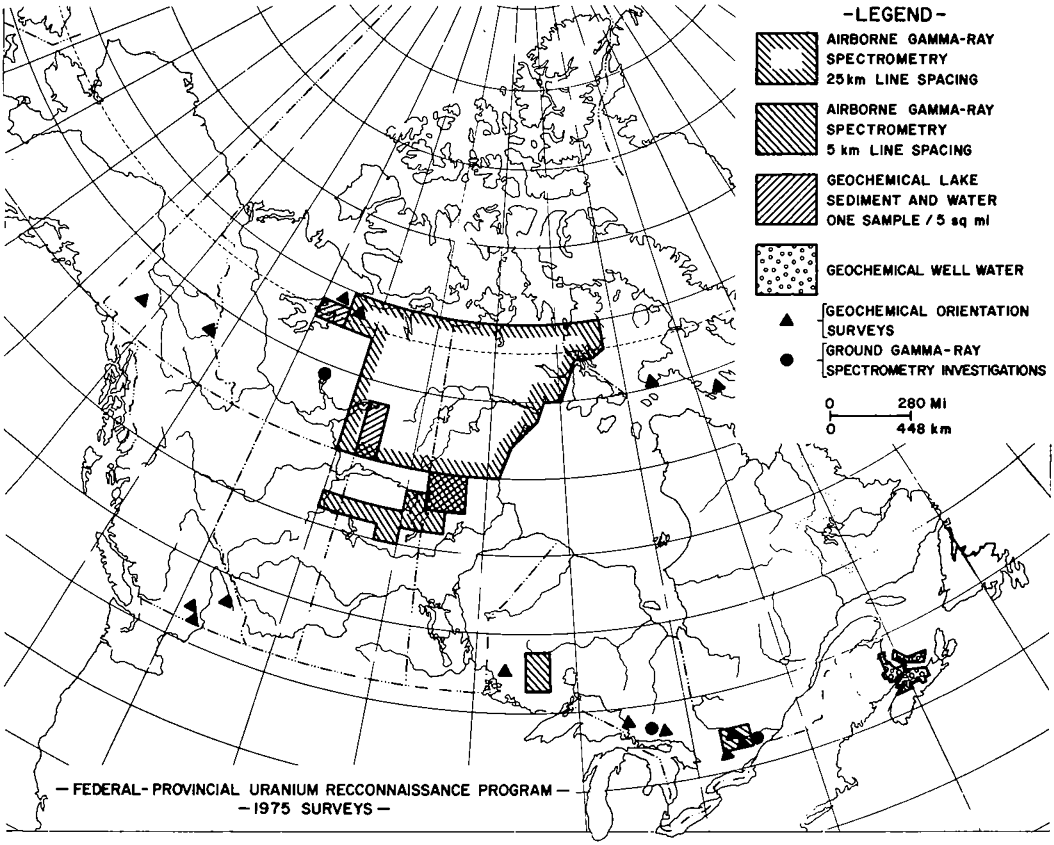
In British Columbia, Consolidated Rexspar Minerals & Chemicals Limited continued with the re-examination of its Birch Island uranium property near Kamloops. The uranium deposit, which also contains significant tonnages of fluorite, was evaluated in the 1950s but never developed. Late in 1975 Consolidated Rexspar announced its intention to carry out further metallurgical test work on the deposit with a view to launching a project feasibility study. Activity also continued in the Beaverdell area east of Penticton where Nissho-Iwai Canada Limited has been exploring for uranium in Tertiary sandstones.

In Saskatchewan, Amok Ltd. continued to explore its 457,000-acre holdings in the Carswell structure within the Athabasca basin. By the end of the summer Noranda Mines Limited had completed its 1975 work on the Thor-Mark V-Brascan property in the Sandfly Lake area, optioned late in 1974. Gulf Minerals Canada Limited continued to explore in the Rabbit Lake area in an effort to add new deposits to those already known on its property. Eldorado extended its exploration activities to several areas outside the Beaverlodge area of Saskatchewan. It was actively involved with Famok Ltd. and Amok Ltd. at Fond du Lac along the northern edge of the Athabasca basin in the northeast corner of Alberta, and in the northwest corner of Saskatchewan where it has a joint venture with the Japanese Power Reactor and Nuclear Fuel Development Corporation. Eldorado was also involved with Conwest Exploration Company Limited in a joint venture* exploring 388, 000 acres along the southern edge of the Athabasca basin. The most promising prospect, however, was the Key Lake discovery about 100 miles southwest of Rabbit Lake on the southern edge of the Athabasca sandstone. In August, high-grade ore intersections were reported from drilling being carried out by Uranerz Exploration and Mining Limited jointly with Inexco Mining Company and the provincial Crown corporation, Saskatchewan Mining Development Corporation.

The Northwest Territories was the scene of substantial activity in 1975. In the St. Germain Lake area, Cominco Ltd. carried out a mapping and drilling program on uranium occurrences discovered in 1974. The company also staked a number of claims in the Goulburn basin in the Bathurst Inlet area following helicopter-borne scintillometer surveys and ground investigations. Rio Tinto Canadian Exploration Limited began geological mapping and scintillometer surveys on claims in the Great Slave Lake area optioned from Vestor Exploration Ltd. Noranda staked and carried out detailed mapping and radiometric surveys on a uranium anomaly near Mazenod Lake that was detected during an airborne reconnaissance survey by the Geological Survey of Canada. BP Minerals Limited, Eldorado, and Imperial Oil Limited were active in the Dismal Lake area. In the Baker Lake area, a large block held under permit by Pan Ocean Oil Ltd. was optioned to Cominco which undertook an extensive program including geological mapping, geophysical surveys and diamond drilling. Areas to the north, west and south of the area optioned by Cominco were intensively explored by Shell Canada Limited, Urangesellschaft Canada Limited and Uranerz Exploration and Mining Limited.

In Ontario, in the Bancroft area, Imperial Oil drilled several properties it holds under option, and Kerr Addison Mines Limited carried out further drilling on the J orebody of the Croft property held under option from Cam Mines Limited. At Elliot Lake, Imperial Oil also explored ground west of Quirke Lake held by Consolidated Morrison Explorations Limited. Also at

* The Conwest Canadian Uranium Exploration Joint Venture: a five-participant exploration program involving Conwest, Eldorado, Empresa Nacional del Uranio, S.A. (ENUSA), Electrowatt Limited, and the Central Electricity Generating Board (CEGB). The joint venture will operate in Canada for five years, each participant contributing $300,000 a year.



Elliot Lake, the Conwest exploration joint venture prepared to conduct a drilling program under an agreement with Lacana Mining Corporation and Driftex Limited.

In Quebec, Imperial Oil continued to drill its Chioak prospect at Jourdan Lake in northern Quebec about 65 miles west of Fort Chimo. Interest in the Mont Laurier area continued as Urangesellschaft explored the property of Scandia Mining & Exploration Ltd. Thirty-five miles northwest of Lac St-Jean, Société québecoise d'exploration minière (SOQUEM) drilled a carbonatite which contains low values in niobium, tantalum, zirconium and uranium. Finally, Eldorado continued its program in the James Bay area with James Bay Development Corporation and SERU Nucléaire (Canada) Limitée.

In the Makkovik-Kaipokok Bay area of Labrador, Urangesellschaft, in partnership with British Newfoundland Exploration Limited (Brinex), continued exploring the zone in which the Kitts and Michelin uranium deposits have been blocked out. Finally, in New Brunswick a number of companies were exploring for uranium in the Carboniferous continental basin.

Of particular significance was the move by Ontario Hydro late in 1975 to participate in two multi-million-dollar uranium exploration programs. The first will be a joint venture with Shell Canada Limited whereby the two partners will each contribute $3.5 million over a five-year period to explore for uranium in the Huronian sediments of Ontario between Sault Ste. Marie and Elliot Lake and in the Baker Lake area of the Northwest Territories. The second program will be a three-year effort with Amok Limited covering the northern portion of Amok's Carswell Dome area holdings; Ontario Hydro will reportedly contribute $2.5 million to this project. Ontario Hydro joins the growing number of North American, European and Japanese electrical utilities which are financing exploration programs to assure their long-term needs.

Pursuant to the agreement of the provincial Ministers of Mines of December 1974, the Geological Survey of Canada embarked on a uranium reconnaissance program, modelled on the highly successful federal-provincial aeromagnetic program. The cost of the program, estimated to be $30 million over 10 years, will be shared by the federal government and the participating provinces. Expenditures in fiscal 1975-76 were expected to total some $2.5 million, of which the federal government will pay about 80 per cent. Airborne gamma-ray spectrometry is used over areas of relatively flat topography where there is some outcrop and thin overburden. Such surveys were carried out in 1975 in the Precambrian area west of Hudson Bay, where wide-interval (25 km) flight lines were used, and in northern Manitoba, northern Saskatchewan and northwestern Ontario where close-interval (5 km) flight lines were used. Regional geochemical surveys, used in areas of extensive overburden, were carried out in areas of northern Manitoba, northern Saskatchewan and northwestern Ontario. Hydro-geochemistry (water well sampling) was used in several areas of the Carboniferous basin of New Brunswick, Nova Scotia and Prince Edward Island.

International developments

Although many countries have been preparing for, or are in the process of conducting, uranium exploration, perhaps the most noteworthy results to date have been in Australia's Northern Territory, which appears to be shaping up as a very large uranium province containing some of the world's richest known deposits. The Jabiluka deposits found by Pancontinental Mining Ltd. (65 per cent) and Getty Oil Development Limited (35 per cent) have reported reserves of 189,000 tons of U_3O_8 in ore grading 7.8 pounds of U_3O_8 a ton.* The Ranger deposits held by Peko Mines Limited (25 per cent), Electrolytic Zinc Company of Australasia Ltd. (25 per cent), and the Australia Atomic Energy Commission (AAEC) (50 per cent) contain reported reserves of about 119,400 tons of U_3O_8.** The Ranger participants had planned for a 3,250-ton-a-year U_3O_8 operation costing about $100 million, to be financed 72.5 per cent by the AAEC and 27.5 per cent by Peko/EZ. Later reports, however, have suggested that the size of the operation could be doubled in view of the delay in development. Queensland Mines Limited, which discovered the Nabarlek deposits, is still

* Getty Oil Company, 1975 Annual Report.

** Other Australian reserve figures (except for Koongarra) from Australian Atomic Energy Commission 1974/75 Annual Report.

Table 2. Uranium production by major producing countries, 1965-1975

	Canada	United States	South Africa	Other[1]	Australia	France[2]	Total[3]
			(short tons U_3O_8)				
1965	4,443 $62,361,377	10,442	2,942	179	370	2,210	20,586
1966	3,932 $54,334,787	9,587	3,286	162	330	2,223	19,520
1967	3,738 $53,021,936	9,125	3,214	273	330	2,272	18,952
1968	3,701 $52,284,580	12,570	3,883	289	330	2,234	23,007
1969	3,854 $53,150,657	12,281	3,979	332	330	2,306	23,082
1970	4,104 . .	12,768	4,119	301	330	2,202	23,824
1971	4,107 . .	12,273	4,189	342	115[4]	3,010	24,036
1972	4,881 . .	12,900	4,001	436	—	3,473	25,691
1973	4,759 . .	13,235	3,410	265^e	—	3,707	25,376
1974	4,795 . .	11,528	3,388	300^e	—	3,814	23,825
1975^p	6,126 . .	11,600	3,600	450^e	—	4,000	25,776

Sources: Statistics Canada; U.S. Bureau of Mines *Minerals Yearbooks;* U.S. Commodity Data Summaries, January 1976, and South African Chamber of Mines.
[1]Includes Argentina, Portugal, Spain and Sweden; [2]Includes Gabon, Malagasy Republic (until 1967), and Niger (from 1970); [3]Totals are of listed figures only, although other countries are known to have produced small quantities of uranium; [4]Estimate, production ceased April 1971.
. . Not available; ^{e} Estimate; — Nil; ^{p} Preliminary.

hoping for approval to develop its property now that the Aborigines have agreed to mining in their Arnhem Land Reserve. Ore reserves have been estimated at 10,500 tons of U_3O_8. Also in the Northern Territory, Noranda Australia Ltd., which is prepared to offer 50 per cent of its holding to Australian interests, wants to proceed with development of its Koongarra deposit, said to contain over 30,000 tons of U_3O_8, which is also in the Arnhem reserve.

To the south of the Northern Territory, in Queensland, Mary Kathleen Uranium Limited is redeveloping its mine, idle since October 1963, for production beginning in 1976. Mary Kathleen is controlled by Conzinc Riotinto of Australia Limited (51 per cent) and the AAEC (42 per cent). The company, which has contracts for 5,225 tons of U_3O_8 for delivery over the period 1975 to 1982, is expected to produce at a rate of 990 tons of U_3O_8 a year; resources in the deposit and in stockpiled ore are stated by the AAEC to be about 10,000 tons of U_3O_8.

Elsewhere in Australia, Western Mining Corporation Limited is hoping to win approval for its plans to develop its Yeelirrie property in Western Australia where it has reported reserves of some 51,200 tons of U_3O_8 in calcrete deposits. In Southern Australia, development of deposits in the Beverly area is also being held in abeyance pending government decisions relative to its new uranium export and development policy. There are three separate sedimentary uranium deposits in the area, near Frome Lake, which have reported reserves of some 17,600 tons of U_3O_8.

Even without new discoveries, therefore, Australia could emerge as a substantial uranium producer with the potential of producing well in excess of the 6,500-ton-U_3O_8-a-year capacity envisaged by the AAEC for 1985. Approval of further development plans was not expected, however, until the new Australian government completes its uranium development and export policy. Indications were that the policy would not be announced until results of a judicial inquiry into the environmental implications of developing the Ranger deposits were known; the inquiry was still under way at year-end.

In the United States, exploration and development drilling rose by 18 per cent in 1975 to 26 million feet, exceeded only by the peak year 1969 when drilling totalled almost 30 million feet. Total drilling expenditures in 1975 were reported at $73.81 million, reflecting a 40 per cent increase in the average cost a foot of drilling. Some 66 companies were involved in this activity, the bulk of which was in Wyoming, New Mexico and Texas. These same companies reported plans for some 35 million and 37 million feet of drilling in 1976 and 1977, respectively. Despite this increase in activity the Energy Research and Development Administration (ERDA) reported at year-end only a 7 per cent increase in United States *reasonably assured resources**, available at up to a forward cost of $30 a pound U_3O_8.

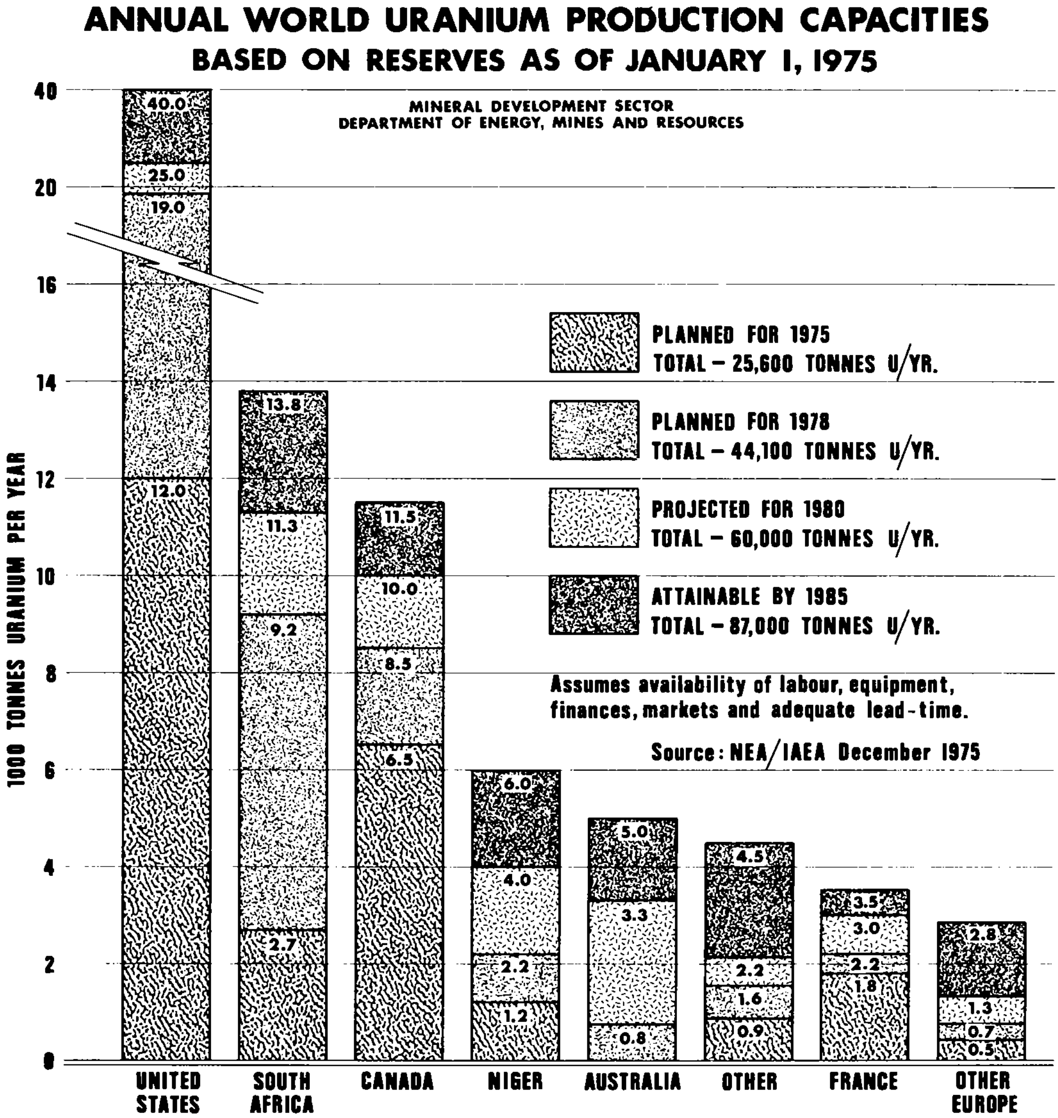
Indicated results of some exploration programs seemed promising, however, and could soon be reflected in more significant increases in reserves. Particularly interesting in this regard was a discovery made by Phillips Petroleum Company in early-1975 in the San Juan Basin of New Mexico at depths of from 3,000 to 3,200 feet. Drilling to December had indicated the presence of 25 million pounds of U_3O_8. The district is well north of the large deposits in and around the Grants area and is therefore doubly significant, being the first really-new uranium area discovered in the United States in many years.

In 1973 ERDA's uranium resource assessment program was expanded to encompass the entire United States. Termed the National Uranium Resource Evaluation Program (NURE), its objective is to evaluate uranium resources and to identify potentially favourable areas for uranium discovery throughout the country. The program is supported by various investigations, including the national airborne radiometric survey, the national hydro-geochemical survey, remote sensing investigations, geologic favourability studies, and geophysical technology development. (See Canadian exploration activity, re Canada's uranium reconnaissance program). NURE expenditures were reported at $5.7 million and $14.0 million for the fiscal years 1975 and 1976, respectively. Although a preliminary report was to be published in 1976 and a more complete report is planned for 1980, results of individual investigations are to be made available to industry throughout the program.

Meanwhile, two new uranium mills are under construction in the United States (United Nuclear Corporation, 3,000 tons a day, at Church Rock, New Mexico and Sohio Petroleum Company/Reserve Oil and Minerals Corp., 1,500 tons a day, Laguna, New Mexico) and a third mill is planned (Western Nuclear Inc., 2,000 tons a day, at Welpinit, Washington). Also of interest, Atlantic Richfield Company began production at an *in situ* operation near George West, Texas, and Wyoming Mineral Corp. (Westinghouse Electric Corporation) was completing a similar operation near Bruni, Texas. Finally, also of significance, was the Uranium Recovery Corporation's (United Nuclear Corp.) operation near Mulberry, Florida which will reach full-scale production in early-1976, recovering uranium as a byproduct from phosphoric acid production.

Significant increases in production were also expected during the next few years in France, where the Commissariat a l'Energie Atomique (CEA) is expanding two of its three existing mills and plans to

* NEA/IAEA resource classification.



construct a third 650-ton-U_3O_8-a-year mill to exploit the Lodève deposit in southern France; in Gabon, where Compagnie des mines d'Uranium de Franceville (COMUF — 20 per cent CEA) is expanding its mill; in Niger, where the existing mill of Société des Mines de l'Air (SOMAIR — 33.5 per cent CEA) is being expanded and a second 2,600-ton-U_3O_8-a-year mill is under construction by Cie. Minière d'Akouta (COMINAK — 34 per cent CEA); and in Namibia (South-West Africa), where Rossing Uranium Limited (45.2 per cent The Rio Tinto Zinc Corporation Limited) was preparing for mining at the rate of 132,000 tons of ore and waste a day beginning in 1976.

These various international developments form the basis for the projection, published in December, 1975 by the Nuclear Energy Agency (NEA), of the Organization for Economic Co-operation and Development, and the International Atomic Energy Agency

(IAEA), that world* production capacity will increase to 57,000 tons** of U_3O_8 a year by 1978 and possibly 78,000 tons of U_3O_8 a year by 1980. Further, the NEA/IAEA estimated that, based on low-cost *reasonably assured resources* (reserves) known as of January 1975, a capacity of 113,000 tons of U_3O_8 a year could be attained by 1985, contingent on the availability of sufficient labour, equipment, finances, base-load contracts and lead-time.

Table 3. World[1] uranium resources, recoverable at costs up to $30 a pound U_3O_8, as of January, 1975

Country	Reasonably Assured	Estimated Additional
	(short tons U_3O_8 x 1000)	
Australia	316	104
Canada[2]	216	544
France	72	52
Niger	65	39
South Africa[3]	359	96
Spain[4]	135	139
Sweden[5]	390	—
United States	600	1,060
Other Europe	25	31
Other Africa	75	26
Other	110	107
Total	2,360	2,200

Source: NEA/IAEA, December 1975.
[1]World excludes, U.S.S.R., Eastern Europe and the People's Republic of China; [2]Canadian figures are expressed in terms of recoverability at various *price* levels, rather than *cost* levels as in the case of other contributors to the NEA/IAEA study; [3]Includes Namibia; [4]A major portion is contained in lignites; [5]Contained in bituminous shales.
— Not reported.

Canadian uranium resources

Pursuant to the announcement by the federal government of new uranium export guidelines in September 1974, a Uranium Resource Appraisal Group (URAG) was established within the Department of Energy, Mines and Resources to assess annually Canada's uranium resources. The first URAG assessment*** was published in August 1975 and reported Canada's uranium resources, as of December 1974, in three classifications, recoverable at up to the world price* and twice the world price (See Table 4).

The URAG assessment is not directly comparable with earlier assessments because of differences in reporting classifications and the more-strictly-defined criteria used by the Group. Because of the latter, some of the resources which had previously been classified as *indicated* are now in the *inferred* category. In addition, the earlier assessments and data included for Canada in the revised NEA/IAEA world study of December 1975 included estimates of resources not covered in the first URAG assessment. While most of the difference is attributable to the geologically *prognosticated* category, some additional *indicated* and *inferred* resources in dormant mines were included in the NEA/IAEA figures as shown in Table 4. Based on these resource estimates, URAG projected that annual Canadian uranium production would increase to 7,550 tons of U_3O_8 in 1976, 12,000 tons in 1980, and 15,000 tons in 1984.

Canadian uranium export guidelines require that sufficient uranium be reserved for domestic needs to enable each nuclear reactor, now operating or planned for operation 10 years into the future, to operate at an average annual capacity factor of 80 per cent for 30 years. On January 1, 1975, it was predicted that reactors totalling 18,400 electrical megawatts (MWe) would be operating in 1985, which would require a total of 92,000 tons of U_3O_8 for their 30-year life-time. Of this total quantity, referred to as the *domestic uranium allocation*, domestic utilities are required to demonstrate that they have contracted for their requirements for the next 15 years. As of January 1, 1975, this utility responsibility was estimated at 26,000 tons of U_3O_8.

Refining

Output of uranium hexafluoride (UF_6) at Eldorado's Port Hope, Ontario refinery increased by 20 per cent in 1975 to 5.4 million pounds of uranium as UF_6. The planned program of expanding the capacity of the UF_6 circuit to 5,000 tons of uranium a year continued, and was expected to be completed sometime in 1976. As one of five commercial uranium refiners in the world, Eldorado converts U_3O_8 concentrates to UF_6 for a variety of customers in Europe, Japan and the United States. UF_6 is the required feed material for the uranium enrichment process.

Output of Eldorado's other principal product, natural ceramic-grade uranium dioxide (UO_2), remained about the same in 1975 at some 1.2 million pounds of uranium as UO_2. Natural UO_2 powder is subsequently pelletized at Canada's two fuel-fabricating facilities (Westinghouse Canada Limited at Port Hope and Canadian General Electric Company Limited at Peterborough, Ontario) for fabrication into fuel elements for Canada's nuclear power program, as well as for first cores for CANDU reactor exports.

* World excludes USSR, Eastern Europe and the People's Republic of China.

** 1 metric ton uranium metal (1 tonne U) = 1.299 short tons U_3O_8.

*** Available free from Information EMR, 588 Booth Street, Ottawa, K1A 0E4, Canada.

* The world price, as of December 1974, was estimated to be $15 a pound U_3O_8.

Table 4. Estimated Canadian uranium resources recoverable at up to twice the world price as of December 1974

<table>
<tr><th rowspan="3">Classification</th><th colspan="3">URAG totals[1]</th><th colspan="3">NEA/IAEA totals</th></tr>
<tr><th colspan="3">Price categories[2]</th><th colspan="3">Price categories</th></tr>
<tr><th>A</th><th>B</th><th>A+B</th><th>A</th><th>B</th><th>A+B</th></tr>
<tr><td colspan="7">(short tons U_3O_8 x 1000)</td></tr>
<tr><td>Measured</td><td>77</td><td>4</td><td>81</td><td rowspan="2">187[3]</td><td rowspan="2">29</td><td rowspan="2">216</td></tr>
<tr><td>Indicated</td><td>107</td><td>17</td><td>124</td></tr>
<tr><td>Inferred</td><td>237</td><td>84</td><td>321</td><td rowspan="2">421[4]</td><td rowspan="2">123</td><td rowspan="2">544</td></tr>
<tr><td>Prognosticated</td><td>—</td><td>—</td><td>—</td></tr>
</table>

Sources: Department of Energy, Mines and Resources, Ottawa, August 1975 and NEA/IAEA, December 1975.
[1]Used for export contract approval, with weighting factors for *measured, indicated* and *inferred* of 1.0, .0.8 and 0.7, respectively; [2]Category A — up to $15 a pound U_3O_8; category B — $15 to $30 a pound U_3O_8. As of December, 1974, the estimated world price for purpose of the URAG assessment was $15 a pound U_3O_8; [3]*Reasonably assured resources* (sum of *measured* plus *indicated).* Includes certain minor resources not covered in URAG assessment; [4] *Estimated additional resources* (sum of *inferred* plus *prognosticated).* URAG assessment did not include *prognosticated* resources.
— Not reported.

Both the UF_6 and the UO_2 circuits are fed by a solvent extraction circuit which converts mine concentrates to nuclear-pure uranium trioxide (UO_3). Due to increased utilization of plant capacity and improved control of chemical circuits, output of uranium in the form of UO_3 almost doubled in 1975 to about 9.1 million pounds.

Eldorado continued to produce a variety of specialized products in its metallurgical facilities from both enriched and depleted uranium. Enriched uranium-carbide fuel was produced for AECL's experimental reactor at Whiteshell, Manitoba, and enriched uranium-aluminum billets were produced for the NRX and NRU experimental reactors at Chalk River, Ontario. Enriched uranium-zirconium booster fuel was also produced for Ontario Hydro's Bruce Nuclear Generating Station. Development work continued on the use of depleted uranium for a variety of industrial applications.

In line with the federal government's policy that all Canadian exports of uranium be in the most advanced form possible, Eldorado directed its long-term planning toward the expansion of its refining capabilities. Two new UF_6 conversion facilities are envisaged by 1980 involving capital expenditures of more than $100 million and sites were under investigation at year-end in both Ontario and Saskatchewan. The company was also considering strengthening its role in other phases of the nuclear fuel cycle.

Uranium enrichment

Significant changes occurred in the uranium enrichment market during the period 1974 to 1975. In the United States, toll-enrichment charges were increased in December 1974 from $36.00 to $42.00 a separative work unit* (SWU), for long-term, fixed-commitment-type contracts, and from $38.50 to $47.80 a SWU, for requirement-type contracts, with additional annual upward adjustments of 2 per cent a year beginning in January 1975. By the end of 1975 enrichment charges had been increased to $53.35 a SWU for long-term fixed commitment contracts and to $60.95 a SWU for requirement-type contracts.

The long-term, fixed-commitment-type contracts were introduced by the Energy Research and Development Administration (ERDA) — then the US Atomic Energy Commission — in September of 1973 to replace the old requirement-type contracts. The new contract criteria are much stricter than the old, requiring utilities to give eight years notice prior to the date of first delivery, to contract for no less than ten years, to make a down payment, equal to one third of the value of the first fuel core in three equal annual payments (a 1,000-MWe** reactor would require a down payment of $3.3 million), and to pay penalties for early contract termination. The requirement-type contracts were signed for the life of the reactor.

* A measure of effort expended to separate a quantity of uranium of a given assay into two components, one having a higher percentage of U^{235}, and one having a lower percentage. Separative work is generally expressed in kilogram units to give it the same dimensions as material quantities, i.e., kilograms or metric tons of uranium. It is common practice to refer to a kilogram separative work unit simply as a separative work unit or a SWU.

** MWe — Megawatt electrical.

In mid-1974, ERDA temporarily stopped signing enrichment contracts in order to review its commitments and capacity. In May 1975, ERDA announced a one-time-only opportunity for utilities to modify their long-term, fixed-commitment contracts without penalty. As a result, four domestic and nine foreign contracts were terminated, 96 of 135 domestic and 54 of 112 foreign contract holders delayed deliveries for an average of 24 months, and 21 domestic and four foreign customers adjusted requirements within their contracts.

ERDA operates its three gaseous diffusion enrichment plants on what is called the "split-tails" concept, whereby the residue coming out of the plant has an assay (operating tails assay) different than the assay (transaction tails assay) used to calculate the charge to the customer. When the operating tails assay is higher than the transaction tails assay, more enriched uranium can be produced with a given amount of separative work. However, this scheme requires more uranium feed than is supplied by the customer and the additional uranium comes from ERDA's surplus uranium stockpile. By operating at a higher tails assay, ERDA has been building up a preproduction reserve of enriched uranium. As of July 1975, ERDA announced the lowering of its operating tails assay from 0.3 to 0.25 per cent U^{235}. This has reduced the amount of feed supplied by ERDA, thus taking some pressure off ERDA's natural uranium stockpile, and allowing some of the 0.3 per cent U^{235} tails that are stockpiled to be recycled.

In mid-1975, in line with a United States goal of having the next increment of enriching capacity developed by private industry, the President sent the Nuclear Fuel Assurance Act (NFAA) to Congress for approval. The Act, whereby the government would guarantee obligations contracted by private uranium enrichers, would offer a strong inducement to private enrichers to go ahead with their plans.

By the end of 1975 four organizations had submitted proposals for new uranium enrichment plants to ERDA. The Garrett Corporation, Centar Associates (Electro-Nucleonics and Atlantic Richfield) and Exxon Nuclear Company, all propose to build and operate 3 million-SWU-a-year private centrifuge enrichment plants. Uranium Enrichment Associates (UEA), which was originally formed by Bechtel Corporation, Westinghouse Electric Corporation and Union Carbide Corporation but is now composed of Bechtel, Goodyear Tire and Rubber and the Williams Company, has proposed the construction and operation of a 9-million-SWU-a-year gaseous diffusion plant.

Several major steps were taken in Europe during 1974 and 1975 toward the establishment of European-based enrichment plants. In March 1974 The Uranium Enrichment Company Limited (URENCO), the operating company formed under a 1970 British-Dutch-West German tripartite agreement, took over the pilot centrifuge plants located at Capenhurst, England and Almelo, Holland. In November 1975 URENCO made its first spot delivery of 18,000 SWU's to the United Kingdom Atomic Energy Authority (UKAEA). URENCO plans to have a total installed capacity of two million SWU's a year by 1980; markets permitting, capacity will be increased to 10 million SWU's a year by 1985. The terms of URENCO contracts were reported to be less stringent than those of ERDA although URENCO became the world price leader after its announcement in March 1975 that its enrichment charges would be $100 a SWU, plus escalation.

Europe's other major enrichment project, EURODIF, based on French gaseous diffusion technology, underwent several changes during the period 1974 to 1975. France had roughly a 50 per cent interest in the project, Italy 24 per cent, and Spain and Belgium the remainder. Sweden, which had been a member, withdrew from the project in 1974 due to delays in its nuclear power development program. Iran, however, agreed to help finance the estimated $3 billion EURODIF plant, in return for an interest in the project. A second French gaseous diffusion project (COREDIF) was announced in mid-1975, financed by EURODIF, the French Commissariat a l'Energie Atomique (CEA) and Iran, whereby a plant would be constructed similar to the one presently under construction by EURODIF. EURODIF expects to reach its full capacity of 10.8 million SWU's a year by 1982.

Several European countries have turned to the U.S.S.R. for toll-enrichment services. Austria signed a 12-year contract for uranium enrichment services and Spain was considering a long-term enrichment contract under which 20 per cent of its enrichment requirements would be supplied by the U.S.S.R. In late-1974, a West German utility signed a long-term Soviet enrichment contract that includes all reload requirements to 1995 for two 1,300 MWe power stations. Smaller contracts had also been signed, notably by Sweden and Finland.

In Canada there were two study projects under way during 1974 and 1975, initiated to examine the possibility of establishing a uranium enrichment facility based on gaseous diffusion technology, Brinco Limited continued with its study which was started in 1971. The second study began in August 1974 when James Bay Development Corporation, Canadian Pacific Investments Limited, Cominco Ltd., and SERU Nucléaire (Canada) Limitée (subsidiary of the CEA) formed a joint company, CANADIF, to investigate the possibility of utilizing power for an enrichment facility from Quebec's James Bay hydroelectric power project. In June 1975, however, Canadian Pacific Investments and Cominco withdrew from the CANADIF project. As of December 1975, future plans of both projects had not been announced.

The Australian government continued to speak about the possibility of an Australian uranium enrichment plant and in November 1974 Australia and Japan announced that they would conduct a cooperative study toward this end. Japan also continued research and development programs on its own behalf with a view to realizing a commercial operation. The Uranium Enrichment Corporation of South Africa Limited (UCOR) has reportedly developed a process of enriching uranium which it considers a unique process. At year-end a pilot plant was near completion and evidently it had been possible to demonstrate the successful operation of the UCOR process on an industrial scale.

Markets and prices

The shift from a buyers' to a sellers' market, which had begun in early 1974, continued and gathered momentum during 1975. Prices for spot sales almost doubled from about $20 early in the year to close to $40 a pound U_3O_8 at year-end, due largely to the increased scarcity of near-term supplies. Quantities of uranium contracted for at these prices however, were comparatively small, reflecting this tight supply situation. Prices actually paid for deliveries in 1975 under earlier contracts were substantially lower. ERDA reported that prices for 1975 delivery under such United States contracts averaged $10.50 a pound U_3O_8. Similar prices under base-price-plus-escalation-type contracts in the non-United States market were likely in the $10 to $15 a pound range; many such contracts were renegotiated in an effort to obtain price relief in the face of rapidly increasing production costs.

In ERDA's 1975 survey of United States marketing activity it excluded from its price survey those contracts which are based on a world market price at time of delivery. Its survey indicated that prices for delivery in 1982 will be in the $10 to $40 a pound range, averaging $16.35 a pound U_3O_8. Market-price-type contracts continued to be popular, however, but just how the world market price should be determined and how rapidly it will rise, became the subject of much controversy. The only area of consensus seemed to be that prices will continue to increase.

Perhaps the factor having the most significant impact on the uranium market in 1975 was the revelation that Westinghouse Electric Corporation could not meet contractual commitments of some 70 million pounds U_3O_8. This material was to be provided in the form of initial and replacement fuel cores to various nuclear power plant customers in the United States and Europe at prices reportedly in the range of $7 to $10 a pound U_3O_8. In September, Westinghouse announced that to meet its shortfall by purchases on the open market at the then-prevailing prices, would be commercially impracticable. It offered to supply 20 per cent of its total commitments under existing terms and, of the remainder, to provide one half at cost of production and one half at current market price. Westinghouse customers responded by instituting lawsuits and the problems remained unsolved at year-end.

The concern of world uranium producers about uranium supply problems led a group of producers and near-producers from outside the United States to form The Uranium Institute in mid-1975. The 16 founding members came from Australia, Britain, Canada, France and South Africa. Consumers of uranium were initially invited to participate as associate members. Late in the year, however, the Institute decided to offer full membership to electric utilities and nuclear fuel companies in order to have the best dialogue among all concerned. The objectives of the Institute are: to promote the development of the use of uranium for peaceful purposes in order to assist in safeguarding the future availability of world energy supplies; to conduct research and to do investigations concerning the world's requirements of uranium, the world's uranium resources and the productive capacity of uranium producers; to provide a forum for the exchange of information concerning the above items; and to consult with governments and other agencies, organizations and entities for the purpose of its research or investigations.

Table 5. Uranium exports approved by Atomic Energy Control Board during 1975

Country	Quantity
	(short tons U_3O_8)
United States	22,850
Japan	21,500
United Kingdom	10,000
West Germany	7,061
Spain	6,250
Finland	2,300
Italy	1,800
Belgium	1,070
Switzerland	650
Total	73,481

Although some Canadian sales were made early in 1975 at prices reportedly as high as $22 a pound U_3O_8, the bulk of Canada's uncommitted supplies was contracted for during the initial surge in the market in 1974. The Atomic Energy Control Board (AECB) announced that it had approved export contracts for the delivery of some 74,000 tons of U_3O_8 during 1975. See Table 5. This brought approved contractual, export commitments to some 110,000 tons U_3O_8. These contracts were the first to be announced by the AECB since implementation of Canada's new export guidelines in September 1974.

Nuclear power developments

Although world nuclear generating capacity continued to increase in 1975, the number of nuclear power plants planned or under construction decreased significantly. See Table 7. Revised power demand forecasts and pressure from environmental groups were largely responsible for the majority of cancellations of planned nuclear power plants, although the capital intensive

Table 6. Exports of uranium concentrates from Canada, 1965-75

	United States[1]	Britain	West Germany	Japan	France	Total
			(thousands of dollars)			
1965	14,749	38,948	–	–	–	53,697
1966	13,761	22,605	–	–	–	36,366
1967	1,047	22,772	–	55	–	23,874
1968	3	26,064	–	–	–	26,067
1969	477	14,997	5,469	3,564	–	24,507
1970	17,031	8,990	–	–	–	26,021
1971	6,213	11,473	–	1	–	17,687
1972	23,040	17,070	–	–	–	40,110
1973	46,794	17,356	–	–	–	64,150
1974	27,974	22,121	–	–	1,215	51,310
1975	28,129	17,937	–	986	–	47,052

Source: Statistics Canada, exports of radioactive ores and concentrates that cleared customs.
[1]For years 1970 to 1975, largely destined for a third country, following enrichment; primarily West Germany and Japan.
– Nil.

nuclear power plants have also been adversely affected by world-wide high inflation rates and economic recession. Despite the high capital costs, however, the unit cost of electricity generated from nuclear fuel was still cheaper than that from fossil fuel plants. For example, the unit energy cost for the four-unit 2,032 MWe Pickering-A Generating Station was 6.34 mills a kilowatt hour in 1974, in contrast to electricity from the Lambton Generating Station, an equivalent sized coal-fired plant which cost 7.04 mills a kilowatt hour. By the end of 1975, comparative figures were 7.03 mills for Pickering and 13.26 mills for Lambton.

In Canada, operating nuclear power stations continued to attract international attention by the excellent operating performance of Ontario Hydro's Pickering-A station. In early 1975 the Pickering-A station set an international record by generating 50.70 million megawatt hours cumulative since start up in 1971. The latter record is remarkable considering that Pickering's Unit 3 was shut down from August 1974 to March 1975 due to cracks found in several rolled-joint positions in the reactor pressure tubes, combined with the fact that Unit 4 was shut down for more than 10 months beginning in May 1975 for a similar problem. The 208 MWe Douglas Point Generating Station continued to supply steam to the Bruce Heavy Water Plant and electrical power to the Ontario Hydro grid throughout 1975. The Nuclear Power Demonstration Station at Rolphton, Ontario also continued to supply power at near-capacity of 22 MWe to the grid.

As a result of Ontario Hydro's capital reduction program announced early in 1976 several of Ontario's nuclear reactor development plans were deferred. Start up of the last units of Pickering-B and Bruce-B* were both deferred by one year to July 1983 and January 1986, respectively. The final completion of the four-unit, 3,200-MWe Darlington Generating Station was deferred by two years to 1988. However, commissioning of the first unit of the four-unit, 3,000-MWe Bruce-A station continued throughout 1975, with first steam to the turbine expected in August 1976.

Quebec is the only other province that has an operating nuclear power station. Located on the St. Lawrence River near Trois-Rivières, Gentilly-1 is a prototype unit which is testing the CANDU-BLW (Boiling Light Water) concept. The unit, rated at 250 MWe, is moderated by heavy water and cooled by light water, which is allowed to boil, the resultant steam being passed directly to the turbine. The chief purpose of Gentilly-1 is to test this direct steam cycle as it may have application in the future for thorium-burning CANDU reactors. Construction of the 600-MWe Gentilly-2 unit continued throughout 1975 at the same site with first operation expected in 1979. The reactor is of the standard CANDU-PHW (Pressurized Heavy Water) design, using heavy water as both moderator and coolant.

In May 1975, the Atomic Energy Control Board (AECB) issued a construction licence to the New Brunswick Electric Power Commission (NBEPC), to proceed with work on the province's first nuclear power station. A 600-MWe unit similar to Gentilly-2 in design will be built at Point Lepreau on the Bay of Fundy. By August 1975, concrete work had begun at the site. New Brunswick will be the first province to have 100 per cent equity in its first nuclear project; 50 per cent of the total cost will be borrowed from the federal government, in line with the federal government's offer to finance the first nuclear station in any province, while the rest will be obtained through normal commercial sources.

* Pickering-B and Bruce-B will be duplications of the respective A stations on the same sites.

Table 7. World nuclear power reactors operating and under construction — 1975

	Operating	Under Construction[1]
	(Net electrical Megawatts — MWe)[2]	
Argentina	320	600
Austria	—	700
Belgium	1,650	2,200
Brazil	—	600
Bulgaria	880	1,700
Canada	2,500	5,700
Czechoslovakia	110	1,700
Finland	—	1,500
France	2,800	18,500
West Germany	3,300	7,600
East Germany	950	900
Hungary	—	900
India	600	900
Italy	550	1,000
Japan	4,310	19,200
Rep. of South Korea	—	600
Netherlands	530	—
Pakistan	120	—
Spain	1,070	5,600
Sweden	3,170	5,500
Switzerland	1,010	1,900
Taiwan	—	3,100
United Kingdom	5,580	6,000
United States	38,320	30,600
USSR	3,300	5,900
Yugoslavia	—	600
TOTAL[3]	71,070	114,500

Sources: *Nuclear Engineering International,* March, 1976; International Atomic Energy Agency, *Power Reactors in Member States,* 1975 edition, *Nuclear News,* August 1975; *CNA Yearbook* 1976.
[1]Under Construction, as used in this table, means that ground has been broken and civil construction has commenced at the reactor site; [2]Rounded; [3]Comparative totals for 1974 were 52,660 MWe and 135,600 MWe, respectively.
— Nil.

The basic design of the CANDU reactor has been directly responsible for the development of the Canadian heavy water* production industry. Two heavy water production plants were operating at year-end. The largest, the 720-metric ton-a-year Bruce-A Heavy Water Plant owned and operated by Ontario Hydro, is located at the Douglas Point-Bruce generating stations. During most of 1975 Bruce-A operated at close to full capacity, producing some 605 metric tons of heavy water. Ontario Hydro had originally planned to build three more identical heavy water plants at the Bruce site, but with the slowdown of nuclear power plant construction and company austerity measures, Bruce-D has been deferred for two years until 1981 and Bruce-C has been cancelled. Construction of Bruce-B continued as planned; first production is expected in 1978.*

The second operating heavy water plant is located at Port Hawkesbury, Nova Scotia. The 360-metric-ton-a-year plant was purchased on May 16, 1975 by Atomic Energy of Canada Limited (AECL) from Canadian General Electric Company Limited. Production of heavy water amounted to only 175 metric tons during the year due to several major outages caused by mechanical failure, and a planned maintenance shutdown. By the end of 1975 reconstruction by AECL of the Deuterium of Canada Limited heavy water plant at Glace Bay, Nova Scotia was essentially complete. First production from this plant, at a rate of 360 metric tons a year, is expected early in 1976.

AECL is also constructing the La Prade heavy water plant in Quebec near the Gentilly-1 and -2 nuclear power stations which will supply the steam required in the production of the heavy water. Although the La Prade plant was originally scheduled for start up in 1979, the construction time has been lengthened by three years, and start up is now expected in 1982; design capacity will be 720 metric tons of D_2O a year.

Table 8. Estimated world[1] nuclear power growth

		1975	1980	1985	1990	2000
		(thousand electrical megawatts)				
United States		40	82	205	385	1,000
OECD-Europe[2]		19	79	212	378	799
Other-OECD[3]		9	24	67	127	281
Non-OECD[4]		1	9	46	114	400
Totals	High	69	194	530	1,004	2,480
	Low	69	179	479	875	2,005

Source: NEA/IAEA, December 1975.
[1]World excludes Eastern Europe, U.S.S.R. and the People's Republic of China; [2]About 80 per cent of total capacity to be installed in France, West Germany, Italy, Spain and United Kingdom; [3]About 25 per cent and 75 per cent of total capacity to be installed in 1975 in Canada and Japan, respectively, increasing to 40 per cent for Canada and decreasing to 56 per cent for Japan by 2000; [4] Africa, South and Central America, Middle East and Southeast Asia.

* Heavy water (D_2O) is water in the molecules of which the place of ordinary hydrogen atoms ($_1H^1$) is taken by the hydrogen isotope deuterium ($_1H^2$); production-grade heavy water has an isotopic content greater than 99.75 mass per cent D_2O.

* Letter notations of plants indicate physical location at the site, not chronological order.

AECL continued to administer all heavy water supplied in Canada under the heavy water pooling arrangement with Ontario Hydro. Under the agreement, which terminates on January 1, 1978, all heavy water produced by either party is consigned to the pool, which was set up to ensure that requirements of both parties will be equitably satisfied.

Late in 1974 the Canadian government announced new, more-stringent conditions in respect to export contracts for Canadian nuclear technology, facilities and material. The safeguards, which apply to both new and existing contracts, are essentially an extension of Canada's requirement that all exports be for peaceful purposes. Purchasers are now required to give binding assurance that Canadian-supplied nuclear material, equipment and technology will not be used to produce a nuclear explosives device.

At the end of 1975 AECL, sole exporter of the CANDU-PHW reactor, was anticipating the renegotiation of its export contract with Argentina's Comision Nacional de Energia Atomica with regards to safeguards and pricing, the latter being necessary due to inflationary increases since its original proposal was accepted in March 1973. AECL and Italimpianti of Italy are jointly building a 600-MWe CANDU plant located at Rio Tercero in Cordoba province. AECL is also proceeding with a contract, signed in January 1975 with the Korea Electric Company, for the supply of a 600-MWe CANDU plant similar to the Argentine plant. As of the end of 1975 several other countries were showing interest in Canadian reactors including Iran, Mexico, Denmark, Ireland, Romania, and Italy, and although no official negotiations had taken place, several requests for detailed information had been received.

Outlook

The outlook, from the producers' viewpoint, may be summed up in one word, "excellent". The complete market turn-around in such a relatively short time is such that there is a ready market for virtually all uranium that can be produced. The rise in price was essential to launching the necessary exploration and development needed to support future increased production to meet the expanding market. In Canada, although the quantities of ore to be delivered to mills will rise, the increase in uranium output will be tempered by the use of lower-grade ores. The addition of the Gulf-Uranerz operation will help to raise production to about 7,500 tons of U_3O_8 in 1976. Additional significant increases will follow as new and expanded facilities are completed and brought up to full operating capacity.

Table 9. Annual world[1] requirements[2] for uranium and for uranium enrichment services

A. Uranium requirements (1,000 short tons U_3O_8 a year)

	Without Pu recycle		With Pu recycle[3]	
Year	High[4] estimate	Low[4] estimate	High estimate	Low estimate
1975	23.4	23.4	23.4	23.4
1980	68.9	62.4	68.9	62.4
1985	131.3	114.4	122.2	106.6
1990	218.9	183.3	200.2	169.0
1995	323.7	262.6	302.9	244.4
2000	406.9	377.2	392.6	306.8

B. Uranium enrichment services (1,000 metric tons of SW a year)

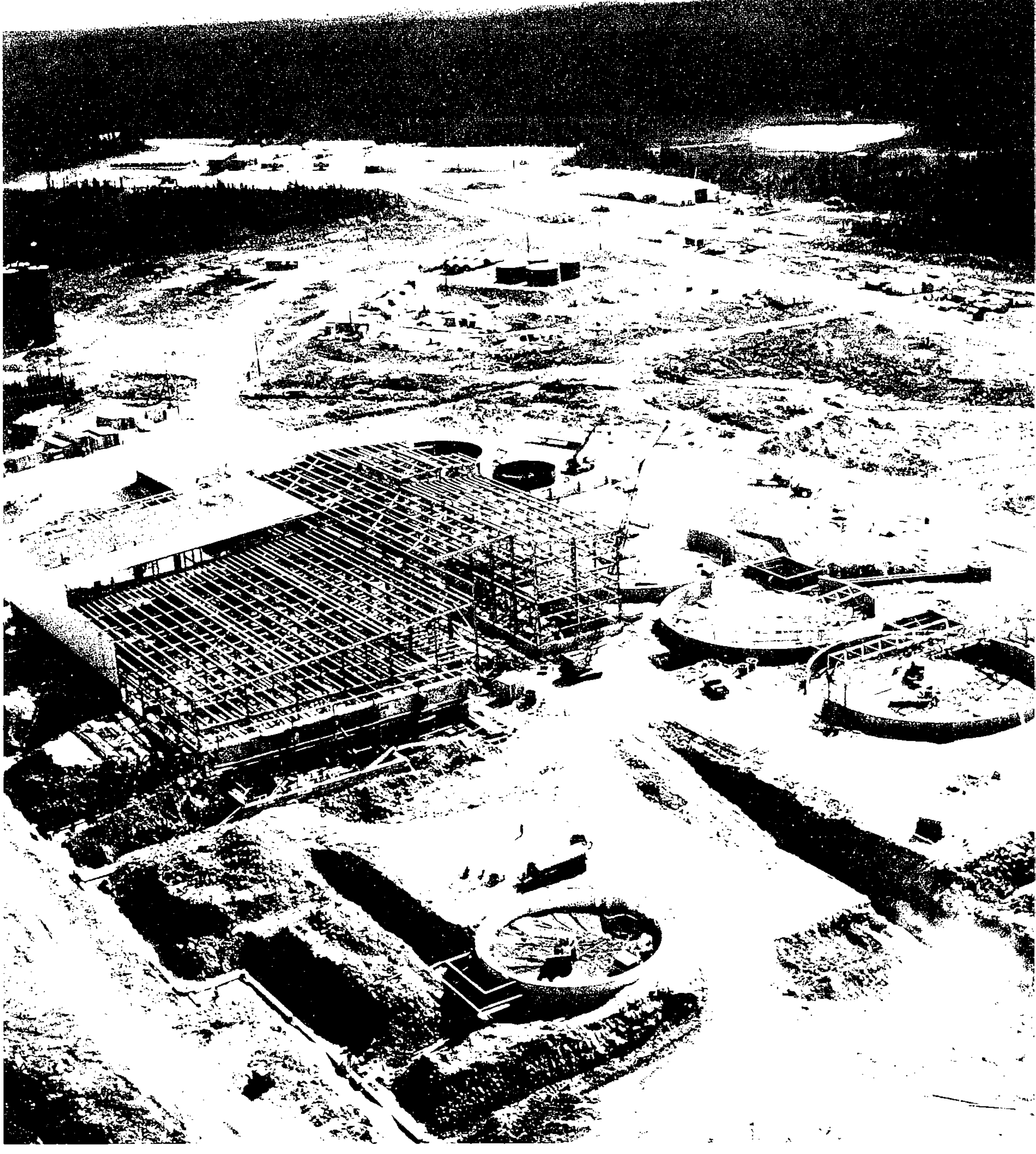
	Without Pu recycle		With Pu recycle	
Year	High estimate	Low estimate	High estimate	Low estimate
1975	10	10	10	10
1980	31	28	31	28
1985	65	57	58	51
1990	112	95	98	84
1995	168	138	151	124
2000	222	175	211	167

Source: NEA/IAEA, December 1975.
[1]World excludes U.S.S.R., Eastern Europe and the People's Republic of China; [2]Assumes 70 per cent load factor and 0.25 per cent U^{235} enrichment tails assay; [3]Plutonium recycle beginning in 1981; [4]High and low estimates refer to rate of power growth.

For the longer term the prospects continue to be promising, although some of the excitement of nuclear power has been lost, particularly when seen in the context of the deferred plans of some United States utilities. The promise of cheap nuclear power after the fivefold increase in world oil prices was based on the assumption that nuclear power generating costs would remain relatively stable and would not rise nearly as quickly as costs for fossil-fueled generating plants. This cost comparison is likely true for power stations completed today where capital costs were incurred largely in the 1960s and early 1970s, and long-term fuel contracts were made at the same time. For future planning, however, the comparison is made somewhat more difficult due to uncertainty about the rising trend in capital costs. Pickering-B, for example, scheduled to be completed nine years after the virtually-identical Pickering-A station, is estimated to cost three times as much. This is quite typical of recent utility experience and has made it increasingly difficult for decision-makers charged with putting such long-lead-time, capital-intensive facilities in place.

Utility executives have also had to face the reality of rising prices of fossil fuels. In this context, consumers are concerned that, in many areas of the world, oil prices do not appear to be related in any way to the cost of finding and producing it. Similarly, consumers have expressed concern that, following the initial adjustment of prices to the $15 a pound U_3O_8 level, uranium prices have also risen too rapidly. While watching the development in the pattern of uranium price increases, many utilities have understandably been looking again at the conventional alternative of coal as well as the more exotic choices of energy generation upon which the world of the future will likely rely.

There is no question that uranium prices in the 1960s and early 1970s were too low, and that a rise in price was necessary to provide incentives for exploration and development. Hopefully, the recent upward movement of uranium prices and the liquidation of excess inventories and capacities have provided the stability the industry required to respond to the need for its expansion. Inasmuch as the long-term question of the growth of nuclear power must be examined in relation to the increasing demand for total energy, and escalating costs are common to all energy systems, the future for nuclear power does not seem to be materially altered. The outlook for uranium, in turn, is such that there will be an increasing demand well into the next century.



The newest uranium project in Canada is the rapidly developing $50 million mine-mill complex of Gulf Minerals Canada Limited and Uranerz Canada Limited at Rabbit Lake, Saskatchewan.
(Photo courtesy Gulf Minerals Canada Limited)

Zinc

D.H. BROWN

The year 1975 was a depression year for the zinc industry throughout the world. Consumption of refined zinc declined 23 per cent from 1974 to 3,875,400 tons in 1975, forcing most refineries to operate at 60 to 65 per cent of capacity by mid-year. Producer inventories rose to a record level of more than 900,000 tons as consumers adjusted raw material inventories downward in line with reduced product demand. Outside North America, the price for good ordinary brand zinc (GOB) quoted in £ sterling declined from a high of 39.5¢ U.S. currency in March to a low of 34.0¢ in September reflcting severe erosion of the £ sterling during 1975. North American prices remained steady at 37¢ in Canada and about 39¢ in the United States. Overall, record levels of inflation and inventories, along with an erosion in real prices and sharply reduced operating levels, combined to create the most difficult year for producers since 1958.

In contrast to the rest of the world, Canadian metal consumption declined only 3.5 per cent to an estimated 117,000 tons*; however, domestic metal production being heavily dependent upon foreign markets was 470,622 tons in 1975, representing 75.0 per cent of available capacity. Metal production in 1974 was almost identical although it was depressed because of labour disputes at the zinc refineries of Cominco Ltd. and Canadian Electrolytic Zinc Limited, whereas in 1975 reduced metal production was related solely to market conditions. The zinc content of Canadian mine production declined 1.3 per cent to 1,350,696 tons during the year.

Mine production

Table 6 provides information on the operation of 31 mining enterprises that produced zinc-bearing ores or concentrates during 1975. Of those listed, Joutel Copper Mines Limited, Normetal Mines Limited, Clinton Copper Mines Ltd., Lynx-Canada Explorations Limited, and Reeves MacDonald Mines Limited closed during the year due to ore exhaustion. These losses were partially offset by new mine capacity from Newfoundland Zinc Mines Limited and La Société minière Louvem inc. In addition, Consolidated Columbia River Mines Ltd. came back into production in 1975 after being closed throughout 1974 due to a snowslide the previous year. Daily mill capacity for all zinc-producing mines in 1975 was 103,820 tons, and with 31,652,274 tons of ore processed during the year, the mines operated at 83.5 per cent of capacity. By comparison, daily mill capacity in 1974 was 105,143 tons which represented 78.5 per cent of capacity. Collectively, on a weighted basis, an average zinc grade in ore of 5.1 per cent was processed in Canada during 1975, of which 82.7 per cent was recovered in the form of zinc concentrates. Typically, the electrolytic refining of zinc in concentrate would recover 90 to 95 per cent of the zinc content in the form of refined metal. Employment in zinc-producing mines which also produced lead and copper totalled 14,351 in 1975 compared with 14,109 in 1974.

Newfoundland

Mill production at the Buchans mines operated by ASARCO Incorporated (formerly American Smelting and Refining Company), was down 32,000 tons to 232,000 tons and treated lower grade ore than the prior year, resulting in zinc-in-concentrate production declining to 22,600 tons in 1975 from 27,267 tons in 1974. Ore reserves at year-end were some 1.1 million tons grading about 12% zinc, 7% lead, 1% copper, 0.02 troy oz. gold per ton and 3 troy oz. silver per ton, sufficient to continue the current level of operation a further five years. The mill, with a capacity of 1,250 tons per day, operates five days a week. The mine is leased from Terra Nova Properties Limited, a wholly-owned subsidiary of Price (Nfld.) Pulp & Paper Limited under an agreement by which mine profits are shared jointly by the operator and the lease holder.

Newfoundland Zinc Mines Limited, which is 63 per cent owned by Teck Corporation Limited, and 37 per cent by AMAX Zinc (Newfoundland) Ltd., commenced milling June 29, 1975 at its new zinc mine located near Daniel's Harbour. Mill capacity at a rate of 1,500 tons per day was achieved in August and it appears capable

*The short ton of 2,000 pounds is used throughout unless otherwise stated.

Table 1. Western world primary zinc statistics, 1973-76.

	1973	1974	1975	1976[e]
	(Thousands of short tons zinc contents)			
Mine production	4968	4892	4932	5205
Metal production	4704	4808	4109	4804
Metal consumption	5373	5038	3875	4483
Refinery capacity[e]	5103	5422	5710	5950
Refinery operating rate	92%	89%	72%	81%

Source: International Lead Zinc Study Group.
[e] Estimated by the Mineral Development Sector, Department of Energy, Mines and Resources, Ottawa.

of operating up to 2,000 tons per day. Capital costs remained within the $18 million pre-construction feasibility study estimate and production commenced 12 months from the decision to proceed with construction. Ore reserves at year-end were 4.5 million tons, averaging 8.8 per cent zinc after dilution, and are sufficient to maintain the operation for at least eight years at full-capacity production. Recovery of zinc is expected to be 96 per cent, with a 63 per cent zinc grade in concentrate being produced. Concentrate shipments to Canadian and United States zinc refineries will be made from Hawkes Bay, 40 miles north of Daniel's Harbour, which can accommodate ocean vessels up to 6,000 tons deadweight capacity. Production in 1975 was 16,638 tons of zinc in concentrate, with 40,300 tons expected in 1976. Tecam Limited, an Ontario corporation 63 per cent owned by Teck Corporation Limited and 37 per cent by AMAX Inc., holds a 25 per cent carried interest in the property. Amax Zinc (Newfoundland) Ltd., is a wholly-owned subsidiary of AMAX Inc.

Nova Scotia

Cuvier Mines Ltd. indicated in its 1974 Annual Report that ore reserves at the Gays River deposit were expected to be about 12 million tons grading 5.9 to 7.0 per cent combined lead-zinc. Imperial Oil Limited has earned a 60 per cent interest in the property by the expenditure of $0.5 million towards exploration and development. Total expenditures on the property were $1.9 million at the end of 1974. In 1975 a $1.5 million underground development program was initiated involving the construction of an 11- by 16-foot decline to extend 2,200 feet into the flat-lying ore structure. By May 1976 the decline had progressed 850 feet into the ore zone. Cuvier Mines Ltd., in order to finance its 40 per cent working interest in the development, has concluded an agreement with Preussag Canada Limited, a wholly-owned subsidiary of Preussag Aktiengesellschaft (AG). In this agreement, Cuvier Mines Ltd. has transferred its 40 per cent interest to a new company, Preuvier Mines Limited; and Preussag Canada Limited, in return for development financing up to $7.0 million, will receive treasury shares of both companies and the right of first refusal to purchase 40 per cent of any concentrate production.

New Brunswick

After a strike-bound year in 1974 Brunswick Mining and Smelting Corporation Limited's mine operations returned to normal levels in 1975, producing 184,100

Table 2. Canada, primary zinc statistics, 1973-76

	1973	1974	1975	1976[e]
	(Thousands of short tons zinc content)			
Mine production	1489	1367	1351	1201
Metal production	587	470	471	561
Metal consumption	125	121	117[e]	132
Refinery capacity[e]	605	614	625	715
Refinery operating rate	97%	77%	75%	78%
Exported mine production(A)	955	957	792	580
Exported metal production(B)	466	326	273	429
Export processing index	33%	25%	26%	38%
(B ÷ (A+B) × 100)				

Source: Statistics Canada
[e] Estimated by the Mineral Development Sector, Department of Energy, Mines and Resources, Ottawa.

Table 3. Canada, zinc production, trade and consumption, 1974-75

	1974		1975p	
	(short tons)	($)	(short tons)	($)
Production				
All forms[1]				
Ontario	480,059	335,080,986	371,339	278,504,000
New Brunswick	165,136	115,264,624	203,143	152,357,000
Northwest Territories	189,472	132,251,480	146,696	110,022,000
Quebec	138,283	96,521,134	131,015	98,261,000
Yukon	87,249	60,899,995	126,879	95,159,000
British Columbia	85,687	59,809,679	109,372	82,029,000
Manitoba	68,877	48,076,390	73,073	54,805,000
Newfoundland	21,045	14,689,531	27,725	20,794,000
Saskatchewan	6,506	4,541,176	4,567	3,426,000
Total	1,242,314	867,134,995	1,193,809	895,357,000
Mine output[2]	1,367,077		1,350,696	
Refined[3]	469,884		470,622	
Exports				
Zinc blocks pigs and slabs				
United States	263,029	175,863,000	178,133	133,760,000
United Kingdom	32,916	20,995,000	62,177	43,365,000
Singapore	4,783	3,207,000	5,824	4,133,000
Belgium-Luxembourg	436	289,000	5,127	4,033,000
Venezuela	2,741	1,871,000	3,907	2,924,000
Brazil	3,825	2,743,000	2,269	1,787,000
West Germany	19	5,000	2,563	1,763,000
France	796	544,000	1,660	1,304,000
Hong Kong	2,759	1,844,000	1,790	1,202,000
Turkey	1,190	654,000	1,533	1,102,000
India	3,535	2,213,000	1,378	876,000
Philippines	875	606,000	834	641,000
Colombia	764	524,000	823	603,000
Taiwan	2,164	1,470,000	926	596,000
Guatemala	1,003	674,000	755	533,000
Pakistan	659	453,000	675	510,000
Bangladesh	110	76,000	455	332,000
Other countries	4,825	3,542,000	1,696	1,094,000
Total	326,429	217,573,000	272,525	200,558,000
Zinc contained in ores and concentrates				
Belgium and Luxembourg	251,762	81,306,000	253,240	96,274,000
Japan	216,243	75,043,000	198,566	80,159,000
West Germany	82,897	24,387,000	111,158	37,401,000
United States	180,800	53,387,000	94,927	37,196,000
Netherlands	50,666	17,990,000	32,198	11,557,000
Italy	31,371	9,777,000	35,158	10,940,000
France	60,248	21,195,000	21,754	9,180,000
Poland	8,431	3,092,000	16,665	6,583,000
South Africa	13,340	4,458,000	5,509	2,393,000
U.S.S.R.	—	—	8,696	2,260,000
Yugoslavia	—	—	4,132	1,469,000
United Kingdom	26,562	8,655,000	3,559	1,342,000
Other countries	34,830	11,359,000	6,042	2,191,000
Total	957,150	310,649,000	791,604	298,945,000

Table 3. (cont'd)

	1974		1975[p]	
	(short tons)	($)	(short tons)	($)
Exports (cont'd)				
Zinc alloy scrap dross and ash (gross weight)				
United States	12,474	4,646,000	11,784	1,821,000
United Kingdom	3,658	1,154,000	3,549	1,123,000
West Germany	819	172,000	915	233,000
Spain	59	38,000	247	108,000
Taiwan	75	14,000	225	88,000
France	254	224,000	370	75,000
Italy	743	497,000	159	72,000
Other countries	3,784	1,207,000	566	137,000
Total	21,866	7,952,000	17,815	3,657,000
Zinc dust and granules				
United States	3,620	3,695,000	2,217	2,178,000
Venezuela	136	143,000	70	94,000
United Kingdom	441	276,000	82	27,000
Nicaragua	8	10,000	7	9,000
Costa Rica	1	1,000	3	4,000
Belgium-Luxembourg	64	22,000	—	—
Colombia	14	19,000	—	—
South Africa	20	7,000	—	—
Total	4,304	4,173,000	2,379	2,312,000
Zinc fabricated material nes.				
United States	3,683	3,522,000	1,561	1,488,000
United Kingdom	749	599,000	235	210,000
Taiwan	38	29,000	75	56,000
Trinidad-Tobago	—	—	34	32,000
Venezuela	62	50,000	23	30,000
Mexico	—	—	19	6,000
Uruguay	—	—	6	5,000
Singapore	344	322,000	—	—
Other countries	413	326,000	1	5,000
Total	5,289	4,848,000	1,954	1,832,000
Imports				
In ores and concentrates	2,343	961,000	10	2,000
Dust and granules	276	270,000	128	147,000
Slabs, blocks, pigs and anodes	7,740	5,604,000	756	606,000
Bars, rods, plates, strip & sheet	2,208	2,264,000	264	395,000
Zinc oxide	2,524	1,647,000	1,630	1,189,000
Zinc sulphate	1,882	630,000	1,401	456,000
Zinc fabricated material nes.	1,420	2,545,000	943	1,778,000
Total	18,393	13,921,000	5,132	4,573,000

Table 3. (concl'd)

	1974			1975^p		
	Primary	Secondary	Total	Primary	Secondary	Total
		(short tons)			(short tons)	
Consumption						
Zinc used for or in the manufacture of:						
Copper alloys (bronze brass, etc.)	15,538					
Galvanizing						
electro	2,417	756	81,242			
hot dip	62,531					
Zinc die-cast alloy	17,791		17,791			
Other products (including rolled and ribbon zinc, zinc oxide)	22,941	7,679	30,620			
Total	121,218	8,435	129,653	. .	. .	. .
Consumer stocks on hand at end of year	15,731	1,490	17,221	. .	. .	. .

Source: Statistics Canada.
[1]New refined zinc produced from domestic primary materials (concentrates, slags, residues, etc.) plus estimated recoverable zinc in ores and concentrates shipped for export. [2]Zinc content of ores and concentrates produced. [3]Refined zinc produced from domestic and imported ores.
^{p}Preliminary; . . Not available for publication; — Nil; nes Not elsewhere specified.

tons of zinc in concentrate. Zinc ore reserves at No. 12 and No. 6 mines at year-end increased to 100.8 million tons grading 9.1% zinc, 3.7% lead, 0.3% copper and 2.8 troy oz. silver per ton on a weighted-average basis, up 8.4 million tons from 1974. Stope development at the No. 6 mine, commencing early in 1976, will permit production to continue from underground ore until 1979, with the open-pit operation phasing out in 1977. The $48 million expansion at the No. 12 underground mine continues on schedule. Progress in 1975 on the new 4,500-foot shaft to be completed in late 1977 included excavation to the final 26-foot-diameter size to 471 feet below surface, shaft concrete to 427 feet below the collar, and shaft steel installed for 227 feet. Ultimate hoisting capacity of 11,000 tons per day in 1979 will be phased in during the period 1979-81, and should raise zinc-in-concentrate capacity from about 210,000 tons in 1975 to about 290,000 tons in 1981 at average ore grade and recoveries. The 1975 average zinc recovery dropped to 75.1 per cent from 76.5 per cent in 1974 due to power failures and inexperienced operators.

Zinc-in-concentrate production at Heath Steele Mines Limited at Little River dropped about 12 per cent from 1974 to 33,219 tons in 1975 due to lower-grade ore being processed during the year. Progress on the new 3,250-foot No. 5 shaft resulted in 2,935 feet being completed by year-end 1975 and it is expected to commence hoisting ore by September 1976, reaching 4,000 tons per day capacity by year-end 1976. Ore production in 1975 came primarily from the old No. 4 shaft, supplemented by tonnage from the underground adit zones of the open pit, which has sufficient ore to continue production until 1977 when the new shaft will be completed. Ore reserves at year-end were 35.2 million tons grading 4.4% zinc, 1.57% lead, 1.18% copper and 1.74 troy oz. silver per ton.

Nigadoo River Mines Limited increased zinc-in-concentrate production at its Beresford mine from 3,672 tons in 1974 to 5,592 tons in 1975, primarily due to a 24 per cent increase in ore processed through the mill. Prior plans to expand the mill to 1,200 tons per day are in abeyance. Ore reserves in the A and C zones at year-end are estimated at 0.7 million tons grading 3.15% zinc, 3.14% lead, 2.3% copper and 3.98 troy oz. silver per ton. Ore reserves in the Anthonian zone discovered in 1974, estimated to be 0.3 million tons grading 4.22% zinc, 3.91% lead, 0.16% copper and 3.69 troy oz. silver per ton, could sustain the mine for two years; however, at 600 tons per vertical foot, the maximum mining rate would be uneconomic at about 60 per cent of current production. In addition, this new ore would have to be hauled more than a mile to the hoist and a direct drift would still have to be about 4,000 feet long. Similarly, much ore in the A and C zones is remote and may not be economic to mine. The Sullivan Mining Group Ltd. owns 96.1 per cent of Nigadoo River Mines Limited.

Texasgulf Inc. is considering the sinking of a 2,800-foot exploratory shaft at its Half Mile Lake zinc-lead-copper property in the Indian Falls area of Northumberland county. The ore body, estimated to contain 6.8

million tons ore grading 6.5% zinc, and 2.5% lead and another 1.0 million tons grading 2.0% copper, is a common boundary deposit with Bay Copper Mines Limited, which is 79 per cent owned by Conwest Exploration Company Limited. Bay Copper optioned its property to Texasgulf Inc. in 1974 on the basis that it commit $100,000 per year for five years on the deposit, with a 10 per cent carried interest for Bay Copper if the property goes into production.

Table 4. Canada mine output, zinc, 1974-75

	1974	1975ᵖ
	(short tons)	
Newfoundland	26,863	38,058
New Brunswick	169,105	220,183
Quebec	153,770	134,379
Ontario	509,965	440,835
Manitoba-Saskatchewan	80,894	82,768
British Columbia	93,947	125,100
Yukon Territory	127,049	139,465
Northwest Territories	205,484	169,908
Total	1,367,077	1,350,696

Source: Statistics Canada.
ᵖPreliminary; — Nil.

Quebec

The Lake Dufault Division of Falconbridge Copper Limited decreased zinc-in-concentrate production to 14,994 tons in 1975 from 17,850 tons in 1974, due to lower grade ore. During 1975, a shaft-sinking plant was constructed and work commenced on the 4,000 foot exploration-production shaft located south-west of the Millenbach mine shaft which will cost about $8 million and take two years to complete. This new shaft is the result of a copper-zinc ore discovery by diamond drilling in 1974 some 2,300 feet underground. Ore reserves at year-end 1975 are estimated at about 1.7 million tons at the Millenbach mine, grading 3.54% copper, 4.33% zinc, 1.49 troy oz. silver per ton and 0.023 troy oz. gold per ton. There also remains some stockpiled ore from the Norbec mine which was closed in December 1974.

The Joutel mine owned by Joutel Copper Mines Limited was closed June 30, 1975 due to ore exhaustion. At closing, the mine employed 79 people, and production to mid-year was 3,973 tons of zinc in concentrate. Kerr Addison Mines Limited owned 63 per cent of the equity in this company, whose sole operation was the Joutel mine.

The Normetal mine of Normetal Mines Limited was closed April 30, 1975 due to ore exhaustion. At closing, the mine employed 387 people, and 1975 production prior to closing was 3,925 tons of zinc in concentrate. Normetal Mines was a wholly-owned subsidiary of Kerr Addison Mines Limited.

La Société minière Louvem inc., a wholly-owned subsidiary of Société québecoise d'exploration minière (SOQUEM) near Val d'Or, Quebec, discontinued copper production in December 1974 due to copper ore exhaustion and commenced mining zinc ore from deposits discovered on the property in 1973, some 2,500 feet west of the shaft. The ore is custom-milled by Manitou-Barvue Mines Limited, and in 1975 some 150,468 tons were processed, producing 33,963 tons of zinc concentrate grading 55.83% zinc, 0.177 troy oz. gold per ton and 3.98 troy oz. silver per ton. Ore production in 1976 is expected to be about 240,000 tons. Ore reserves at December 31, 1975 were 2.3 million tons grading 7.29% zinc, 0.03 troy oz. gold per ton and 0.92 troy oz. silver per ton. The concentrate production has been purchased by the Philipp Brothers Division of Englehard Minerals & Chemical Corporation, which sells the production internationally.

Zinc-in-concentrate production from the Val d'Or property of Manitou-Barvue Mines Limited declined to 3,045 tons in 1975 from 3,770 tons in 1974, due primarily to lower-grade ore. The mill processed 244,995 tons of proprietary ore, plus custom copper-zinc ore produced by the nearby Louvem property. Ore reserves at year-end were 0.9 million tons grading 2.16% zinc, 0.36% lead, 0.020 troy oz. gold per ton and 3.72 troy oz. silver per ton. The concentrate production has been purchased by the Philipp Brothers Division of Englehard Minerals & Chemical Corporation which sells the production in the United States.

The Matagami property of Mattagami Lake Mines Limited produced at a lower rate in 1975, reflecting the decline in metal production at Canadian Electrolytic Zinc Limited in which it owns a 51.67 per cent interest. Zinc-in-concentrate production was 87,118 tons compared with 97,794 tons in 1974. The mine reports improved efficiency through circuit control of the flotation operation by a process computer, resulting in increased metal recoveries. Ore reserves at December 31, 1975 were 10.8 million tons grading 8.4% zinc, 0.65% copper, 0.015 troy oz. gold per ton and 0.95 troy oz. silver per ton.

Orchan Mines Limited increased zinc-in-concentrate production at its Matagami property from 14,821 tons in 1974 to 16,490 tons in 1975 due to increased ore tonnage being processed. Mining operations at the Garon Lake Division ceased at year-end 1975 due to ore exhaustion; however, the production shaft at the Norita Division was completed at a depth of 1,680 feet and milling of development ore was to commence in January 1976. Ore reserves at year-end are estimated to be 3.2 million tons grading 6.9% zinc, 0.8% copper, 0.01 troy oz. gold per ton and 0.8 troy oz. silver per ton.

The Sullivan Mining Group Ltd., reported zinc-in-concentrate production declining in 1975. The Cupra Division, which also custom-mills ore for the wholly-

Table 5. Canada, zinc production, exports and consumption, 1966-75

	Production		Exports			
	All Forms[1]	Refined[2]	In ores and concentrates	Refined	Total	Consumption[3]
	(short tons)					
1966	964,106	382,605	591,322	256,153	847,475	107,052
1967	1,111,453	405,136	735,705	297,652	1,033,357	107,779
1968	1,159,392	426,728	855,818	318,707	1,174,525	115,978
1969	1,207,625	466,357	804,665	307,394	1,112,059	118,681
1970	1,251,911	455,471	892,043	351,454	1,243,497	105,641
1971	1,249,734	410,643	891,092	312,462	1,203,554	115,433
1972	1,252,642^r	524,885	765,647^r	410,053^r	1,175,700^r	130,764
1973	1,352,074	587,038	944,127	466,142^r	1,410,269^r	124,869^r
1974	1,242,314	469,884	957,150	326,429	1,283,579	121,218
1975^p	1,193,809	470,622	791,604	272,525	1,064,129	. .

Source: Statistics Canada.
[1]New refined zinc produced from domestic primary materials (concentrates, slags, residues, etc.) plus estimated recoverable zinc in ores and concentrates shipped for export. [2]Refined zinc produced from domestic and imported ores. [3]Refined primary zinc only, reported by consumers.
^{p}Preliminary; ^{r}Revised; . . Not available.

owned subsidiary D'Estrie Mining Company Ltd. and the 38.7 per cent-owned Clinton Copper Mines Ltd., had a 45-per cent drop in output due to reduced zinc grade and lower ore production. Ore reserves at the Cupra Division can sustain mining to year-end 1977 at most, and at December 31, 1975 there were 46,800 tons grading 3.63% zinc, 2.66% copper, 0.51% lead, 0.014 troy oz. gold per ton and 1.022 troy oz. silver per ton. Production by D'Estrie was down slightly to 3,116 tons due to lower-grade ore, even though the amount of ore mined increased. Year-end ore reserves at D'Estrie were 0.9 million tons grading 1.52% zinc, 2.78% copper, 0.56% lead, 0.015 troy oz. gold per ton and 1.107 troy oz. silver per ton. Clinton Copper Mines Ltd. ceased production in August, 1975 due to ore exhaustion, and produced 1,215 tons of zinc in concentrate prior to closure.

Selco Mining Corporation Limited in a joint venture with Pickands Mather & Co. discovered significant copper-zinc-silver mineralization in the Detour River area of Brouillan Township of north-western Quebec. Approximately 3,000 claims have been staked and preliminary estimates indicate 34.5 million tons ore in the surface A zone grading 2.3% zinc, 0.39% copper, 0.009 troy oz. gold per ton and 1.04 troy oz. silver per ton and 3.4 million tons in the underground B zone, open at depth, grading 4.49% copper, 0.8% zinc, and 1.15 troy oz. silver per ton. Pickands Mather & Co. is a wholly-owned subsidiary of Moore McCormack Resources Inc. Selco Mining Corporation Limited is 94.2 per cent owned by Selcast Canadian Holdings Ltd., which in turn is a wholly-owned subsidiary of Selection Trust Limited and Associates, a member of the Charter Consolidated Limited group. A $13 million program involving shaft sinking and detailed underground examination will be undertaken in 1976.

Lemoine Mines Limited, a wholly-owned subsidiary of Patino Mines (Quebec) Limited which in turn is wholly-owned by Patino N.V., completed underground development as well as the milling plant and ancillary facilities in 1975 at its property 16 miles southeast of Chibougamau. Mill tune-up commenced at year-end and production should begin early in 1976. Ore reserves are estimated to be 0.6 million tons grading 10.8% zinc, 4.5% copper, 0.138 troy oz. gold per ton and 2.7 troy oz. silver per ton. Production in 1976 is expected to be 100,000 tons of ore of the above grades, which will be trucked to the Chibougamau concentrator of the parent company for processing.

Ontario

The Sturgeon Lake joint venture operated by Falconbridge Copper Limited commenced production in February, 1975 after several months of start-up problems. The mill was expanded in 1975 from 800 to 1,200 tons per day at a cost of $850,000 and in 1976 the plant will be expanded at a cost of $385.000. The mill treated 376,682 tons of ore in 1975, producing 24,753 tons of zinc in concentrate. The mine site is located in the Sturgeon Lake area of north-western Ontario and is five miles east of Mattabi Mines Limited and adjacent to the Group 23 property of Mattagami Lake Mines Limited. The joint venture includes Falconbridge Copper Limited with a 13.4 per cent interest, NBU Mines Limited with a 6.6 per cent interest, and Sturgeon Lake Mines Limited with an 80 per cent interest and becomes effective once the capital development costs have been recovered. The last company is 67 per cent

(text continued on page 589)

Table 6. Principal zinc mines in Canada 1975 and (1974)

Company and Location	Mill or Mine Capacity	Grade of Ore Milled: Zinc	Grade of Ore Milled: Lead	Grade of Ore Milled: Copper	Grade of Ore Milled: Silver	Ore Produced	Zinc Concentrate Produced	Grade of Zinc in Concentrate	Contained[1] Zinc Produced	Destination[2] of Zinc Concentrate[e]
	(tons ore/day)	(%)	(%)	(%)	(oz/ton)	(tons)	(tons)	(%)	(tons)	
Newfoundland										
ASARCO Incorporated Buchans Unit Buchans	1,250 (1,250)	10.54 (11.24)	5.92 (6.28)	0.95 (1.01)	3.03 (3.25)	232,000 (264,000)	35,283 (42,326)	55.16 (55.30)	22,600 (27,267)	8,9,11,12 (8,9,11,12)
Newfoundland Zinc Mines Limited Daniel's Harbour	1,500 —	6.3 —	— —	— —	— —	243,148 —	24,988 —	62.5 —	15,638 —	6,12 —
New Brunswick										
Brunswick Mining and Smelting Corporation Limited Bathurst	10,000 (10,000)	7.11 (6.70)	2.95 (2.96)	0.40 (0.38)	2.33 (2.32)	3,427,239 (2,607,965)	354,333 (255,965)	51.95 (52.23)	155,729 (112,971)	9 (9)
Heath Steele Mines Limited Newcastle	3,100 (3,100)	3.99 (4.39)	1.54 (1.72)	1.03 (1.04)	1.73 (1.98)	1,089,443 (1,085,495)	64,344 (73,229)	47.99 (48.07)	33,219 (37,758)	8,9,12 (6,8,12)
Nigadoo River Mines Limited Bathurst	1,000 (1,000)	2.69 (2.74)	2.55 (2.53)	0.25 (0.33)	3.44 (3.74)	255,078 (205,691)	10,559 (8,739)	44.96 (44.72)	5,592 (3,672)	9 (9)
Quebec										
Falconbridge Copper Limited Lake Dufault Division Noranda	1,550 (1,500)	3.35 (3.54)	— (—)	2.50 (2.38)	1.12 (0.99)	560,775 (553,187)	28,480 (29,660)	52.65 (51.99)	14,994 (17,850)	8 (8)

Table 6. (cont'd)

Company and Location	Mill or Mine Capacity	Grade of Ore Milled: Zinc	Grade of Ore Milled: Lead	Grade of Ore Milled: Copper	Grade of Ore Milled: Silver	Ore Produced	Zinc Concentrate Produced	Grade of Zinc in Concentrate	Contained[1] Zinc Produced	Destination[2] of Zinc Concentrate
	(tons ore/day)	(%)	(%)	(%)	(oz/ton)	(tons)	(tons)	(%)	(tons)	
Quebec (cont'd)										
Joutel Copper Mines Limited Joutel	. .	6.13	. .	. .	1.28	87,499	8,355	51.25	3,973	4
	(700)	(6.81)	(.)	(.)	(.)	(101,396)	(10,038)	(51.67)	(5,187)	(6)
Kerr Addison Mines Limited (Normetal Mines Limited) Normetal	1,000	5.86	—	0.58	1.28	82,150	7,635	52.13	3,925	6
	(838)	(4.58)	(—)	(0.97)	(1.1)	(250,492)	(18,694)	(51.68)	(9,662)	(6)
La Société minière Louvem inc. Louvicourt	. .	. .	. .	. .	. .	150,468	33,963	55.83	15,359	12
	—	—	—	—	—	—	—	—	—	—
Manitou-Barvue Mines Limited Val d'Or	1,600	1.81	0.30	. .	2.46	244,955	5,761	52.8	3,045	6
	(1,600)	(2.20)	(0.35)	(.)	(2.58)	(225,303)	(6,695)	(56.3)	(3,770)	(6)
Mattagami Lake Mines Limited Matagami	3,850	7.3	—	0.62	0.86	1,285,703	162,237	53.1	87,118	3
	(3,850)	(7.5)	(—)	(0.62)	(0.88)	(1,406,265)	(183,559)	(52.7)	(97,794)	(3,6,12)
Orchan Mines Limited Orchan and Garon Lake mines Matagami	1,900	4.65	—	1.19	0.48	421,805	31,655	52.09	16,490	3
	(1,900)	(4.78)	(0.05)	(1.18)	(0.50)	(364,030)	(27,155)	(52.38)	(14,821)	(3)
Sullivan Mining Group Ltd. Stratford Centre Cupra Division	1,400	4.12	0.47	2.24	0.972	56,058	3,334	56.58	1,886	6
	(1,500)	(4.78)	(0.59)	(2.49)	(1.112)	(87,478)	(5,907)	(57.32)	(3,386)	(6,9)
D'Estrie Mining Company Ltd.	—	2.12	0.54	2.57	1.116	180,094	5,521	56.49	3,119	. .
	—	(2.72)	(0.61)	(2.56)	(1.155)	(162,081)	(6,338)	(56.99)	(3,612)	(6,9)

Table 6 (cont'd)

Company and Location	Mill or Mine Capacity	Grade of Ore Milled: Zinc	Grade of Ore Milled: Lead	Grade of Ore Milled: Copper	Grade of Ore Milled: Silver	Ore Produced	Zinc Concentrate Produced	Grade of Zinc in Concentrate	Contained[1] Zinc Produced	Destination[2] of Zinc Concentrate
	(tons ore/day)	(%)	(%)	(%)	(oz/ton)	(tons)	(tons)	(%)	(tons)	
Quebec (cont'd)										
Clinton Copper Mines Ltd.	— —	2.49 (2.50)	0.47 (0.48)	2.59 (2.64)	0.876 (0.951)	73,535 (52,656)	2,234 (1,494)	54.36 (52.81)	1,215 (789)	6 (6,9)
Ontario										
Falconbridge Copper Limited Sturgeon Lake Joint-Venture Sturgeon Lake	1,200 (1,200)	9.07 (7.59)	1.17 (1.09)	2.78 (2.05)	5.31 (. .)	376,682 (82,592)	47,206 (. .)	52.44 53.54)	24,753 (4,266)	12 (12)
Selco Mining Corporation Limited South Bay Division Uchi Lake	500 (500)	11.18 (11.96)	— (—)	1.82 (1.92)	. . (3.08)	168,334 (195,000)	31,589 (38,318)	54.46 (54.22)	17,205 (20,500)	6 (6,12)
Texasgulf Canada Ltd. Kidd Creek mine Timmins	10,000 (10,000)	8.20 (9.20)	0.25 (0.30)	1.71 (1.75)	3 10 (3.17)	. 3,630,224 (3,723,865)	504,749 (580,534)	51.49 (52.14)	276,814 (302,702)	6,7,12 (5)
Lynx-Canada Explorations Limited Long Lake mine Parham	— (200)	— (12.17)	— (—)	— (—)	— (—)	— (39,589)	— (24,231)	— (19.76)	— (4,921)	— (6)
Mattabi Mines Limited Sturgeon Lake	3,000 (3,000)	7.34 (8.81)	0.70 (0.91)	0.97 (0.91)	3.23 (4.31)	1,074,923 (1,138,965)	127,892 (164,896)	53.69 (54.43)	68,864 (90,703)	6,12 (3,6,12)
Noranda Mines Limited (Geco Division) Manitouwadge	5,000 (5,000)	3.54 (4.72)	. . (0.20)	1.84 (1.72)	1.44 (1.56)	1,599,333 (1,826,704)	84,141 (132,400)	52.84 (53.50)	51,954 (70,965)	3 (3,6)

Table 6. (cont'd)

Company and Location	Mill or Mine Capacity	Grade of Ore Milled: Zinc	Lead	Copper	Silver	Ore Produced	Zinc Concentrate Produced	Grade of Zinc in Concentrate	Contained[1] Zinc Produced	Destination[2] of Zinc Concentrate
	(tons ore/day)	(%)	(%)	(%)	(%)	(oz/ton)	(tons)	(tons)	(%)	(tons)
Ontario (cont'd)										
Willroy Mines Limited	1,400	3.82	0.22	0.42	1.56	327,353	20,964	52.5	11,007	3
Manitouwadge Division	(1,700)	(3.06)	(0.23)	(0.42)	(1.37)	(394,154)	(19,826)	(52.66)	(10,441)	(6)
Manitouwadge										
Manitoba and Saskatchewan										
Hudson Bay Mining and Smelting Co., Limited										
Flin Flon		2.0		1.8	0.7	573,775				
Anderson Mine		0.2		3.2	0.2	110,072				
Chisel Lake		10.8	0.4	0.7	1.1	119,639				
Osborne Lake		1.8		2.8	0.2	191,490				
Dickstone Lake		2.5		2.6	0.4	118,197				
Schist Lake		4.4		4.1	0.8	45,303				
Stall Lake		0.7		4.2	0.3	163,366				
Ghost Lake		10.0	0.6	1.4	1.0	43,963				
Flin Flon	8,500	3.0	0.2	2.4	0.6	1,470,157	54,636	48.6	33,697	2
	(8,500)	(3.22)	(0.12)	(2.34)	(0.63)	(1,574,948)	(69,550)	(48.6)	(42,451)	(2)
Sherritt Gordon Mines Limited										
Fox Mine	2,840	1.81	—	1.74	. .	1,007,183	22,492	48.35	13,969	2
Lynn Lake	(3,000)	(1.98)	(—)	(2.10)	(0.33)	(1,008,111)	(19,033)	(49.39)	(9,400)	(2)
Ruttan Mine	10,000	1.90	—	0.96	. .	3,340,794	97,977	50.12	53,054	2,7
Ruttan Lake	(10,000)	(1.68)	(—)	(1.07)	(0.20)	(3,358,257)	(79,951)	(49.21)	(39,343)	(2,7)
British Columbia										
Cominco Ltd.,	8,000	4.16	3.85	—	1.27	2,207,848	164,006	47.66	83,080	1
Sullivan Mine	(10,000)	(4.49)	(4.11)	(—)	(1.41)	(1,416,489)	(114,154)	(48.24)	(58,335)	(1)
Kimberley										

Table 6 (cont'd)

Company and Location	Mill or Mine Capacity	Grade of Ore Milled: Zinc	Lead	Copper	Silver	Ore Produced	Zinc Concentrate Produced	Grade of Zinc in Concentrate	Contained[1] Zinc Produced	Destination[2] of Zinc Concentrate
	(tons ore/day)	(%)	(%)	(%)	(oz/ton)	(tons)	(tons)	(%)	(tons)	
British Columbia (cont'd)										
H.B. Mine Salmo	1,200 (1,200)	3.40 (3.7)	0.56 (1.1)	— (—)	. . (.)	453,145 (256,121)	25,225 (15,750)	53.2 (52.3)	13,999 (8,604)	1 (1)
Consolidated Columbia River Mines Ltd. Ruth Vermount Mine Golden	500 (500)	. . (—)	. . (—)	. . (—)	. . (—)	11,308 (—)	377 (—)	52.20 (—)	237 (—)	1 (—)
Kam-Kotia Mines Limited Silmonac mine Sandon	120 (140)	4.82 (4.16)	5.66 (3.28)	— —	17.48 (12.76)	12,045 (12,034)	835 (747)	51.21 (51.11)	519 (446)	6 (6)
Reeves MacDonald Mines Limited Remac Annex Mine	1,000 (1,000)	3.07 (3.84)	0.58 (1.18)	— (—)	0.60 (0.64)	35,507 (195,565)	1,768 (12,526)	51.49 (51.98)	937 (6,820)	6 (6)
Teck Corporation Limited Beaverdell Mine Beaverdell	110 (110)	0.39 (0.52)	0.38 (0.41)	. . (0.003)	9.30 (9.06)	38,469 (37,184)	263 (287)	38.12 (39.90)	150 (188)	1 (1)
Western Mines Limited Lynx and Myra Falls Buttle Lake V.I.	1,100 (1,100)	7.59 (8.05)	1.42 (1.48)	1.12 (1.28)	4.49 (4.52)	287,393 (297,290)	34,416 (37,346)	52.4 (51.14)	19,942 (21,910)	6,9 (6,7)
Yukon Territory										
Cyprus Anvil Mining Corporation Faro	10,000 (10,000)	5.41 (5.60)	4.03 (4.51)	— (—)	. . (.)	3,225,223 (2,925,000)	230,494 (207,437)	50.80 (50.29)	147,127 (116,281)	7 (7)

Table 6. (concl'd)

Company and Location	Mill or Mine Capacity	Grade of Ore Milled: Zinc	Grade of Ore Milled: Lead	Grade of Ore Milled: Copper	Grade of Ore Milled: Silver	Ore Produced	Zinc Concentrate Produced	Grade of Zinc in Concentrate	Contained[1] Zinc Produced	Destination[2] of Zinc Concentrate
	(tons ore/day)	(%)	(%)	(%)	(oz/ton)	(tons)	(tons)	(%)	(tons)	
Yukon Territory (cont'd)										
(also bulk lead-zinc concentrate)							77,113 (72,294)	29.34 (30.35)	(included above)	7,8 (7.8)
United Keno Hill Mines Limited Elsa	500 (225)	1.15 (1.15)	4.03 (4.22)	– (–)	34.96 (37.73)	90,860 (93,232)	613 (527)	51.53 (53.0)	316 (273)	6 (6)
Northwest Territories										
Pine Point Mines Limited Pine Point	10,000 (11,000)	4.88 (5.28)	2.37 (2.58)	– (–)	– (. .)	3,904,677 (4,135,380)	301,447 (357,457)	57.93 (56.66)	177,694 (205,484)	1,6,12 (1,2,12)

[1]Total zinc contained in all concentrates. [2]Destination of concentrates: (1) Trail; (2) Flin Flon; (3) Valleyfield; (4) Belledune; (5) Timmins; (6) U.S.A.; (7) Japan; (8) Germany; (9) Belgium; (10) France; (11) Britain; (12) Unspecified and other countries.
– Nil; . . Not available

Table 7. Prospective zinc-producing mines

Company and Location	Year Production Expected	Mill or Mine Capacity	Indicated Ore Reserves	Grade of Ore Zinc	Grade of Ore Lead	Grade of Ore Copper	Grade of Ore Silver	Remarks
		(tons ore/ day)	(tons)	(%)	(%)	(%)	(oz/ton)	
Quebec								
Lemoine Mines Limited Chibougamau	1976	400	625,000	10.8	. .	4.5	2.7	Production scheduled to start in January 1976.
Noranda Mines Limited Magusi Mine, Magusi	1978	1,500	468,000	8.33	—	0.33	—	Zinc zone. Copper zone contains 1,569,000 tons grading 2.1% copper
Orchan Mines Limited, Norita Mine	1976	—	1,965,300	6.4	—	0.6	1.0	Milling of ore to commence January 1976.
Radiore No. 2	1976	—	153,300	1.0	—	2.0	—	Mining program subject to higher copper prices
Ontario								
Mattagami Lake Mines Limited, Lyon Mine Sturgeon Lake	1978	—	4,030,000	6.66	0.63	1.15	3.39	Ore to be processed at Mattabi Mines Ltd.
Manitoba								
Hudson Bay Mining and Smelting Co., Limited, Snow Lake area Centennial mine	1976		1,460,000	2.6	—	2.06	0.7	Shaft to 1,400 ft. level by December 1975
Westarm Mine	1977	—	700,000	0.6	—	4.63	. .	Shaft to 1,400 ft. level by December 1975.
British Columbia								
Northair Mines Ltd. Brandywine Falls	1976	300	459,000	3.09	2.28	0.33	3.2	Startup expected early 1976
Northwest Territories								
Nanisivik Mines Ltd. Strathcona Sound	1976	1,500	6,900,000	14.1	1.4	—	1.77	Construction commenced in 1974. Satisfactory progress on construction to date. Initial output is expected in late 1976 with shipments commencing in 1977.

. . Not available; — Nil.

Table 8. Indicated zinc deposits under exploration

Company and Location	Indicated Ore Tonnage	Grade of Ore: Zinc	Lead	Copper	Silver	Remarks
	(tons)	(%)	(%)	(%)	(oz/ton)	
New Brunswick						
Anaconda Canada Limited, Bathurst, Caribou property	50,000,000	4.43	1.7	0.47	. .	In temporary production 1971 and in 1974. Feasibility studies continue on bringing this property into production (late 1970's?).
Chester Mines Limited, Newcastle	1,600,000	2.12	0.82	0.63	. .	Ore available for open-pit mining.
	3,300,000	. .	—	0.82	—	
	13,000,000	. .	—	0.77	. .	Ore available for underground mining. Feasibility study completed in 1970.
Key Anacon Mines Limited, Bathurst	1,950,000	5.87	2.18	0.24	2.31	Mine partly developed. Re-evaluation of property in 1970 led to decision to defer placing the property into production at that time.
Canex Placer Limited Portage Lakes area, Restigouche property	3,000,000	6.0	4.5	. .	2.50	Partly recoverable by open pit.
Texasgulf Inc. Half Mile Lake	6,800,000	6.5	2.5	. .	. .	
Nova Scotia						
Cuvier Mines Ltd., Gays River	12,000,000	5.6	2.3	—	. .	Optioned to Imperial Oil Limited. Under exploration since 1972. Full potential not determined yet. Intensive program continuing 1976 including production feasibility study.
Quebec						
Noranda Mines Limited, Barraute Mine	4,000,000	3.5	. .	. .	1.2	Former producer (1952-1957). Property optioned from Manitou-Barvue Mines Limited in 1974. Exploration in progress.
Selco Mining Corporation Limited, Frotet Lake	1,200,000	3.7	—	1.8	1.0	Optioned from Muscocho Explorations Limited which retains 20% interest.

Table 8. (cont'd)

Company and Location	Indicated Ore Tonnage	Grade of Ore				Remarks
		Zinc	Lead	Copper	Silver	
	(tons)	(%)	(%)	(%)	(oz/ton)	
Quebec (cont'd)						
Phelps Dodge Corporation of Canada, Limited Lagauchetiere deposit	1,500,000	4.0	—	1.0	1.0-1.5	Additional mineralization present at depth. Exploration in progress.
Selco Mining Corporation Limited Picklands Mather & Co., Brouillan property	(A) 34,500,000 (B) 3,400,000	2.3 0.8	. . . .	0.39 4.49	1.04 1.15	(A) zone on surface — (B) zone underground. A $13 million program including shaft sinking and underground examination to be undertaken in 1976.
Ontario						
Giant Yellowknife Mines Limited Errington and Vermilion Lake mines, Sudbury area	4,418,500 and 9,038,317	3.9 3.82	1.0 0.99	1.33 1.14	1.61 1.58	Extensive underground development in 1961-1967 period. Ore difficult to concentrate. Reserves only for underground explored areas with low pyrite and high pyrite ore respectively.
Manitoba						
Stall Lake Mines Limited, Snow Lake	672,000	2.28	. .	5.38	. .	Falconbridge Nickel Mines Limited is joint owner of this property. Exploration completed in 1971. Feasibility study on production completed. Decision deferred.
Saskatchewan						
Bison Petroleum & Minerals Limited, Brabant Lake	4,330,000	4.43	. .	0.64	. .	Further exploration planned.
British Columbia						
Noranda Mines Limited Revelstoke	3,300,000	3.0	. .	4.5	. .	
Yukon Territory						
Hudson Bay Mining and Smelting Co., Limited, Tom deposit MacMillan Pass	7,000,000	8.4	8.1	—	2.75	Underground work through adit including diamond drilling in 1970-1972. Further development planned.

Table 8. (cont'd)

Company and Location	Indicated Ore Tonnage	Grade of Ore Zinc	Lead	Copper	Silver	Remarks
	(tons)	(%)	(%)	(%)	(%)	
Yukon Territory (cont'd)						
Kerr Addison Mines Limited Swim Lake deposit, Vangorda Creek	5,000,000		9.5 (Pb+Zn)	. .	1.50	A group claims.
Kerr Addison Mines Limited Aex Minerals Corporation Grum deposit Vangorda Creek	30,000,000	. .	About 10 (Pb+Zn)	. .	2.0	Similar to Cyprus Anvil lead-zinc deposit. Possibly 50 million tons ore. $6.25 million program undertaken in 1975 including 2,600 ft. decline into ore body.
Vangorda Mines Limited, Vangorda Creek	9,400,000	4.96	3.18	0.27	1.76	Feasibility study made. No further exploration.
Canex Placer Limited Howards Pass, Summit Lake	Very large	About 5-10 (Pb+Zn)				Joint exploration with United States Steel Corporation. Drilling to continue in 1976. One estimate shows 300,000,000 tons.
Barrier Reef Resources Ltd Goz Creek Bonnet Plume Area	12,000,000	8.0	. .	. .	. .	Represents A and B zones with 13 other zones to be explored. Drilling continues
Northwest Territories						
Arvik Mines Ltd., Little Cornwallis Island	25,000,000	14.1	4.3	. .	1.0	Cominco Ltd. — 75% and Bankeno Mines Limited — 25%. Underground program (5,300 foot adit) and metallurgical tests completed. Feasibility study completed. Decision on mining to be made in 1976.
Buffalo River Exploration Limited	1,350,000	9.6	3.4	—	. .	Feasibility study for joint production with Coronet Mines Ltd. completed in 1971. Decision was made not to put the property into production.
Welcome North Mines Ltd. Bear Property, Godlin Lake	20,000,000	About 7-8 (Pb+Zn)		. .	0.5-1.0	Drilling continues

Table 8. (concl'd)

Company and Location	Indicated Ore Tonnage	Grade of Ore				Remarks
		Zinc	Lead	Copper	Silver	
	(tons)	(%)	(%)	(%)	(oz/ton)	
Northwest Territories (cont'd)						
Bathurst Norsemines Ltd., Hackett River, Bathurst Inlet area	20,000,000	. .	. .	. .	. .	Optioned to Cominco. Large deposit in three zones with high zinc and silver values. Under active exploration from 1970 and $2 million expended to December 1975. Wright Engineers performing $100,000 feasibility study 1976.
Texasgulf Inc. Izok Lake	7,000,000	14.8	1.2	3.15	1.85	Central ore zone which is open to east. Remaining two zones not delineated and drilling to resume April 1976.
No. 10 Hood River	500,000	3.5	. .	5.0	1.0	Drilling to resume 1976.
No. 41 Hood River	300,000	4.12	. .	1.57	0.52	Indicated to 200 ft depth and drilling to resume 1976.

. . Not available; — Nil.

owned by Falconbridge Copper Limited and 33 per cent by NBU Mines Limited. Total expenditures prior to start-up were $18.3 million. Ore reserves are estimated at December 31, 1975 to be 1.8 million tons grading 10.19% zinc, 2.8% copper, 1.42% lead, 5.82 troy oz. silver per ton and 0.021 troy oz. gold per ton.

Table 9. 1975 Canadian primary zinc metal production

	Refined Zinc Production	Annual Rated[e] Capacity	Per cent Utilization
	(tons)	(tons)	
Canadian Electrolytic Zinc Limited Valleyfield, Quebec.	117,700	146,000	80.6
Cominco Ltd. Trail, British Columbia	194,000	280,000	69.3
Hudson Bay Mining & Smelting Co. Ltd. Flin Flon, Manitoba	65,117	79,000	82.4
Texasgulf Canada Ltd. Hoyle, Ontario	93,000	120,000	77.5
Total, Canada	468,117	625,000	75.0

Source: Published 1975 Company Annual Report.
[e] Estimated by the Mineral Development Sector, Department of Energy, Mines and Resources, Ottawa.

The South Bay Division of Selco Mining Corporation Limited, located in the Uchi Lake area of northwestern Ontario, reported a decline in production to 17,205 tons of zinc in concentrate in 1975 from 20,500 tons in 1974 due to lower tonnage milled and lower-grade ore. Declining ore reserves approaching exhaustion have been replenished by new zones of ore discovered in 1973-74, called the No. 11 zone between the 600-foot and 900-foot levels, and the No. 12 zone below the 900-foot level. The deepening of the shaft to 2,100 feet which started in May 1974 had reached 1,817 feet below the collar by year-end 1975. Ore reserves at year-end are expected to be about 0.3 million tons above the 900-foot level grading 11.96% zinc, 1.9% copper and 2.4 troy oz. silver per ton. Estimates of No. 12 zone ore are not available.

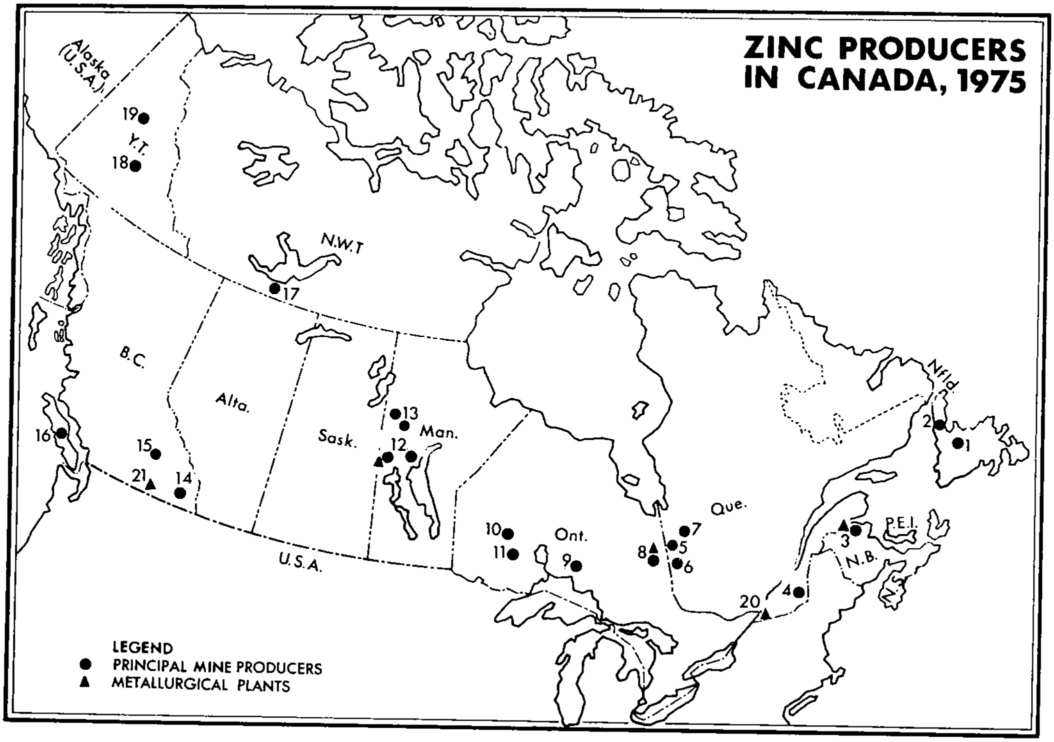
The Kidd Creek mine, wholly-owned by Texasgulf Canada Ltd. (formerly Ecstall Mining Limited), a subsidiary of Texasgulf Inc., was operated below capacity in 1975 due to poor market conditions for metal. Ore milled in 1975 declined only from 3.7 to 3.6 million tons, but the grade mined deteriorated from 9.2% to 8.2% zinc, resulting in 276,814 tons of zinc in concentrate being produced in 1975, compared with 302,702 tons in 1974. Ore reserves at December 31, 1975 were estimated to be 92 million tons above the 2,800-foot level grading 5.92% zinc, 2.7% copper, 0.21% lead and 2.31 troy oz. silver per ton. There were an additional 6 million tons of inferred ore above the 2,800-foot level, and diamond drilling below this level intersected ore to at least the 5,000-foot level, with the ultimate depth and dimensions of the ore body still unknown. The grade of copper increases with depth, while the grade of zinc decreases. The expansion program to increase mine production and processing of ore to five million tons per year by the addition of the No. 2 underground mine, and a fourth circuit to the concentrator, is on schedule. By year-end the No. 2 shaft, which ultimately will reach the 5,300-foot level, had been completed to 2,600 feet. The 6-foot pilot-borehole extended to the 2,800-foot level. On the surface, the No. 2 headframe was ready for installation of hoisting machinery and good progress had been made on the collarhouse service building extension and ore handling facilities. The expansion program is expected to cost about $100 million by completion in about 1978-79. In 1975 the open pit supplied about 2.27 million tons of ore to the mill, with the balance from underground; however, the open pit is scheduled for closure by year-end 1976 when all ore will come from the No. 1 underground. A backfilling plant completed in 1975 will commence backfilling of mined-out stopes in mid-1976, using a lean concrete mix with open-pit waste rock and slag. This will permit 100 per cent recovery of ore once it is in operation.

Zinc-in-concentrate production at Mattabi Mines Limited declined sharply to 68,864 tons in 1975 from 90,703 tons in 1974 due to lesser tonnage of lower-grade ore being milled in order to adjust production to contracted sales. Development of the underground portion of the orebody commenced in 1975 with the driving of a 3,500-foot access decline. Mattabi Mines Limited is 60 per cent owned by Mattagami Lake Mines and 40 per cent by the Abitibi Paper Company Ltd. and is located in the Sturgeon Lake area of northwestern Ontario. Reserves of ore at December 31, 1975 were 9.9 million tons grading 6.7% zinc, 0.74% copper, 0.7% lead and 2.62 troy oz. silver per ton.

Table 10. Canada, producers' domestic shipments of refined zinc, 1973-75

	1973	1974	1975[p]
		(short tons)	
1st Quarter	33,169	42,060	26,343
2nd Quarter	37,125	43,646	45,088
3rd Quarter	36,322	26,851	52,567
4th Quarter	41,920	35,617	40,482
Total	148,536	148,174	164,480

Source: Statistics Canada.
[p] Preliminary.



Principal Producers
(numbers refer to numbers on map)

1. ASARCO Incorporated (Buchans Unit)
2. Newfoundland Zinc Mines Limited
3. Brunswick Mining and Smelting Corporation Limited.
   Heath Steele Mines Limited.
   Nigadoo River Mines Limited.
4. Sullivan Mining Group Ltd.
5. Joutel Copper Mines Limited
6. Falconbridge Copper Limited, Lake Dufault Division.
   Manitou-Barvue Mines Limited.
   Kerr Addison Mines Limited, (Normetal mine).
   La Société minière Louvem Inc.
7. Mattagami Lake Mines Limited.
   Orchan Mines Limited.
8. Texasgulf Canada Ltd.
9. Noranda Mines Limited (Geco Division).
   Willroy Mines Limited.
10. Selco Mining Corporation Limited.
11. Mattabi Mines Limited.
    Falconbridge Copper Limited. (Sturgeon Lake Joint Venture).
12. Hudson Bay Mining and Smelting Co., Limited (Chisel Lake, Osborne Lake, Stall Lake, Dickstone, Ghost Lake, Anderson Lake, Schist Lake, Flin Flon).
13. Sherritt Gordon Mines Limited (Fox Lake mine and Ruttan mine).
14. Cominco Ltd. (Sullivan mine and H.B. mine).
    Teck Corporation Limited (Beaverdell mine).
    Reeves MacDonald Mines Limited (Annex mine).
    Kam-Kotia Mines Ltd. (Silmonac mine).
15. Consolidated Columbia River Mines Ltd., (Ruth Vermont Mine).
16. Western Mines Limited.
17. Pine Point Mines Limited.
18. Cyprus Anvil Mining Corporation.
19. United Keno Hill Mines Limited.

Metallurgical Plants

8. Texasgulf Canada Ltd., Hoyle.
20. Canadian Electrolytic Zinc Limited, Valleyfield.
12. Hudson Bay Mining and Smelting Co., Limited, Flin Flon.
21. Cominco Ltd., Trail.

Development at the Lyon Lake Division Mattagami Lakes Mines in Ontario continues, with the surface plant complete and shaft sinking well under way. Initial production at 1,000 tons per day is scheduled for September 1977 when spare capacity will be available at the concentrator owned by neighbouring Mattabi Mines Limited. Ore reserves at the Lyon Lake property are 4.0 million tons grading 6.66% zinc, 1.15% copper, 0.63% lead, 0.010 troy oz. gold per ton and 3.39 troy oz. silver per ton.

The Geco Division of Noranda Mines Limited, located at Manitouwadge, reduced production 10 per cent beginning in June and the milling operation was also suspended for two weeks in August to correspond to a shutdown at Canadian Electrolytic Zinc, in which Noranda now has a direct interest of 22.67 per cent. Zinc-in-concentrate production declined from 70,965 tons in 1974 to 51,954 tons in 1975 due to lower-grade ore and lesser tonnage milled. The major capital expenditure in 1975 was the second phase of waste water treatment for environmental protection and control, which included the erection of a reactor clarifier system. Ore reserves at year-end were 28.1 million tons grading 3.62% zinc, 1.87% copper, and 1.52 troy oz. silver per ton.

Willroy Mines Limited, which belongs to the Little Long Lac Gold Mines Limited group through the ownership of Willroy shares by Lake Shore Mines Limited (46.7%) and Wright-Hargreaves Mines Limited (18.9%), increased zinc-in-concentrate production slightly to 11,007 tons in 1975. Ore reserves at year-end 1975 were 0.6 million tons grading 3.91% zinc, 0.47% copper, 0.16% lead and 1.54 troy oz. silver per ton, sufficient for about two years' continued production. Reserves were extended in 1975 by development of the No. 1 ore zone on the 550-foot level at the Willecho shaft.

Manitoba and Saskatchewan

At Hudson Bay Mining and Smelting Co., Limited in Flin Flon, Manitoba eight of the nine mines in the Flin Flon-Snow Lake area operated continuously, but ore production at Osborne Lake, Chisel Lake, and Stall Lake declined due to considerable development work. Ore production totalled 1,470,105 tons, down 6 per cent from 1974 due to a continuing shortage of trained underground miners. Remnants and pillars were the main sources of ore for Flin Flon, Ghost Lake, and White Lake. Reserves at White Lake are sufficient for about six months' operation. The Dickstone mine was shut down in August for economic reasons which precluded $2.5 million being spent to develop reserves estimated to be 340,000 tons grading 4% zinc, 2.36% copper, plus gold and silver values below the 1,150-foot level. Schist Lake production was reduced due to poor ground conditions forcing abandonment of lower levels and will close in early 1976 due to ore exhaustion. The shaft at the Chisel Lake mine was deepened 267 feet and a crusher and improved loading facilities will be installed; however, production during the last four months of 1975 was reduced while this development work was under way. Similarly, studies are under way to increase production from deeper levels at the Stall Lake mine. Ore production at Osborne Lake increased almost 50 per cent above 1974, and 1975 saw the completion of over 9,000 feet of stope development at this property. At Anderson Lake production was lower due to the necessity of changing mining methods from open stope to cut-and-fill, and because of inexperienced labour. Development at the Centennial mine resulted in the main shaft being sunk to 1,411 feet by year-end. Eight level-stations were completed, the loading pocket and sump were excavated and all equipment was installed. At year-end, lateral development had started on most levels and exploration drilling had increased estimates of ore reserves to 1.46 million tons grading an estimated 2.06% copper, 2.6% zinc, 0.7 troy oz. silver per ton and 0.04 troy oz. gold per ton. Development at the Westarm mine resulted in the installation of all surface plant and equipment. The work of sinking the main shaft, which started June 1, 1975, was down 1,457 feet by year-end with seven level-stations excavated. Ore reserves at Westarm are estimated to be 0.7 million tons grading 4.63% copper and 0.6% zinc. Over-all, zinc-in-concentrate production in 1975 declined to 33,697 tons from 42,451 tons in 1974. Proven ore reserves for the group at year-end 1975 were 17.5 million tons grading 2.8% zinc, 2.77% copper, 0.2% lead, 0.033 troy oz. gold per ton and 0.52 troy oz. silver per ton. The company also plans to develop the Lost Lake ore zone sometime in the future.

Zinc-in-concentrate production reported by Sherritt Gordon Mines Limited increased at both Fox and Ruttan mines to 13,969 tons and 53,054 tons respectively. At the Fox mine at Lynn Lake, the deepening of the shaft was completed to 2,200 feet in 1975 and will continue to 2,400 feet. Installation of an enlarged ventilation system and the expansion of office buildings were completed. Ore reserves at year-end 1975 declined to 8.7 million tons grading 2.08% zinc and 1.92% copper. At Ruttan Lake, diamond drilling commenced for proposed underground development. Originally the Ruttan operation had planned to phase-in the underground mine during the 1979-1981 period to coincide with ore exhaustion in the open pit. Year-end ore reserves were 43.6 million tons grading 1.45% zinc and 1.45% copper. Production at both mines is to be reduced in 1976.

British Columbia

The Sullivan mine and the H.B. mine owned by Cominco Ltd. returned to normal production levels in 1975 following a four-month strike in 1974. Zinc-in-concentrate production in 1975 increased to 83,080 tons at Sullivan and 13,999 tons at H.B. The Sullivan mine at Kimberley completed the first phase of a $4 million program designed to improve efficiency and control hot ore caused by oxidation. Construction also proceeded on a major tailings dyke and on water recycling systems. Underground, 1,000 feet of internal ramp was completed as part of a five-year conversion program from slusher mining to predominantly trackless draw-point methods. The H.B. mine at Salmo completed the raising and extension of the dam in 1975. Ore reserves at the two mines at year-end 1975 were reported as 59 million tons grading 10.8% combined lead and zinc.

The Ruth Vermont Mines Limited near Golden re-opened in October 1975 after being closed by snow-slides in January 1974. In 1975 the mine milled 11,308 tons of ore to produce 377 tons of zinc in concentrate. Ore production in 1976 is expected to be 63,000 tons. The mine is controlled by Consolidated Columbia River Mines Ltd. which owns 55 per cent of the equity, with 30 per cent held by Mura Development Corp. of Canada and 15 per cent by Copperline Mines Ltd. Year-end ore reserves were 0.3 million tons proven and 1.1 million tons probable and inferred grading 5.53% zinc, 5.03% lead and 5.95 troy oz. silver per ton. The mine was closed for the winter months in November 1975 and work will resume in March 1976.

The Silmonac mine at Sandon which is owned by Kam-Kotia Mines Limited retained 1975 production at the 1974 level by mining 12,045 tons of ore to produce 519 tons of zinc in concentrate. Year-end ore reserves were reported as 10,000 tons probable and the company planned for limited diamond drilling and development in 1976.

The Annex mine at Remac owned by Reeves MacDonald Mines was closed March 31, 1975 due to ore exhaustion. The mine employed 100 people at closing and zinc-in-concentrate production prior to closing was 937 tons. The Gulf Resources & Chemical Corporation subsidiary, Bunker Hill Company, controlled 60.33 per cent of the shares in Reeves MacDonald Mines.

The Beaverdell mine owned by Teck Corporation Limited maintained 1975 production at the 1974 level, mining 38,469 tons of ore to produce 263 tons of zinc in concentrate. Reserves are not reported, but production in 1976 is expected to remain unchanged.

Production at the Lynx and Myra Falls mines of Western Mines Limited on Vancouver Island declined slightly to 34,416 tons of zinc in concentrate due to lower-grade ore and lower throughput of ore. Ore reserves at year-end were 1.7 million tons grading 7.9% zinc, 1.2% copper, 1.2% lead, 0.09 troy oz. gold per ton and 4.2 troy oz. silver per ton.

Noranda Mines Limited discovered a small orebody near Revelstoke with indicated reserves of 3.3 million tons grading 4.5% copper and 3.0% zinc which the company has reported should developed into a small but profitable operation.

The gold-lead-zinc property of Northair Mines Ltd. near Brandywine Falls produced some development ore in late 1975 but the 300-ton-per-day concentrator is not expected to start up until early 1976. Ore reserves are estimated to be 459,000 tons grading 3.09% zinc, 2.28% lead, 0.33% copper, 3.2 troy oz. silver per ton and 0.46 troy oz. gold per ton. The mine will produce separate lead and zinc concentrates.

Yukon Territory

Cyprus Anvil Mining Corporation was formed in April 1975 by the amalgamation of Cyprus Anvil Mining (formerly Anvil Mining Corporation Limited) and Dynasty Explorations Limited on a share-for-share basis. The new company is controlled by Cyprus Mines Corporation which hold 63.05 per cent of the issued shares. Production in 1975 increased to 3.2 million tons of ore, producing 147,127 tons of zinc in concentrate. Comparison to 1974 is difficult due to a 33-day walkout in May and June. Ore reserves at year-end are estimated to be about 47 million tons grading 8.7 per cent combined lead-zinc and 1.0 troy oz. silver per ton.

Production at United Keno Hill Mines Limited remained fairly comparable to 1974 and although ore throughput from the Husky, Elsa, Keno, Dixie and Townsite mines decreased slightly, zinc-in-concentrate production increased slightly to 316 tons in 1975. Year-end ore reserves were reported to be 121,727 ton grading 4.7% lead, 1.1% zinc and 39.3 troy oz. silver per ton. The exploration budget remains unchanged at about $1.0 million per year and production in 1976 is expected to be about the same as 1975.

Kerr Addison Mines Limited and Aex Minerals Corporation, which jointly own 60 per cent and 40 per cent interests respectively in the Grum lead-zinc-silver deposit north of Vangorda Creek near Faro, undertook a $6.25 million program in 1975 which included the sinking of a 2,600-foot exploratory decline into the ore zone, surface diamond drilling and a feasibility study including metallurgical investigation, preliminary plant design and environmental considerations. Ore reserves are indicated to exceed 30 million tons, and although some ore could be mined by open-pit methods, the bulk of the ore is underground. The deposit is very similar to the nearby lead-zinc Faro mine of Cyprus Anvil Mining Corporation which grades about 8.7 per cent combined lead-zinc and 1.0 troy oz. silver per ton. Kerr Addison also holds claims on adjacent ground on which diamond drilling on 72 claims known as the A Group, or the Swim Lake deposit, indicated five million tons of ore grading 9.5 per cent combined lead-zinc and 1.5 troy oz. silver per ton, with minor copper and gold values. Similarly, Vangorda Mines Limited, which is 69 per cent owned by Kerr Addison, has held adjacent claims at Vangorda Creek since 1956 on which diamond drilling had indicated ore reserves of 9.5 million tons grading 4.96% zinc, 3.18% lead, 0.27% copper and 1.76 troy oz. silver per ton. In 1973 and 1974 the claims held by Vangorda and Kerr Addison, excluding the A Group, were all optioned to Aex Minerals,. Neither of these deposits were economically feasible on their own according to past feasibility studies; however, should the Grum deposit progress to a mining venture these two properties would probably become viable as support operations.

Northwest Territories

Zinc-in-concentrate production at Pine Point Mines Limited declined in 1975 to 177,694 tons due to lower-grade ore and lower throughput in the mill. During 1975 a 600,000-ton orebody was discovered and the 50-ton truck fleet was replaced by an 85-ton truck fleet. Ore reserves at December 31, 1975 were 39 million tons grading an estimated 5.7% zinc and 2.2% lead. The company is owned 69 per cent by Cominco.

Arvik Mines Ltd., owned 75 per cent by Cominco Ltd. and 25 per cent by Bankeno Mines Limited, reported that although discussions continued throughout 1975 with the federal government, progress was disappointingly slow and it was hoped the unresolved issues would be settled in 1976. The Polaris deposit, located on Little Cornwallis Island, contains an estimated 25 million tons ore grading 14.1% zinc, 4.3% lead and 1.0 troy oz. silver per ton.

Diamond drilling by Texasgulf Inc. during 1975 indicated three sulphide zones in a deposit which occurs partly under Izok Lake and partly under a 750-foot-long island in the southern portion of this shallow lake. The central zone, which remains open to the east, contains over seven million tons of indicated ore grading 14.8% zinc, 3.15% copper, 1.2% lead and 1.85 troy oz. silver per ton. The remaining two zones have not been delineated in any direction and drilling will resume in April 1976. The top of the orebody is at, or near, the surface, thereby making it suitable for open-pit operation. At the Hood River No. 10 prospect, 25 miles north of Izok Lake, a mineralized zone was defined containing 0.5 million tons assaying 3.5% zinc, 5.0% copper and 1.0 troy oz. silver per ton. In the same vicinity the No. 41 massive sulphide deposit was discovered, with 0.3 million tons of indicated ore to a depth of 200 feet assaying 4.12% zinc, 1.57% copper and 0.52 troy oz. silver per ton. Texasgulf now holds over 1,500 claims — approximately 75,000 acres — in the area of the Izok Lake and Hood River deposits and on which several other promising mineral showings will be investigated in 1976.

Progress continued at Nanisivik Mines Ltd. at Strathcona Sound on Baffin Island with production scheduled for late 1976. In 1975, a major sea-lift of construction materials was underaken to construct surface plant, a power plant and housing accommodation. Likewise, wharf, airport and road construction commenced during the year, all of which are scheduled for completion in 1977. Ore reserves are estimated to be 6.9 million tons grading 14.1% zinc, 1.4% lead and 1-2 troy oz. silver per ton. Zinc recoveries are anticipated to be 95per cent, producing 140,000 tons per year concentrate assaying 60% zinc, 0.23% cadmium and 9-10 troy oz. silver per ton. Lead recoveries are anticipated to be 90%, producing 14,000 tons per year concentrate assaying 65-70% lead and 1-2 troy oz. silver per ton. Currently, ownership of the mine is divided, with Mineral Resources International Limited holding 59.5%, Metallgesellschaft A.G. 11.25%, Billiton B.V. 11.25% and the federal government 18%. Texasgulf Inc., retains a 35 per cent carried interest in the property as original owner once all development costs have been recovered. Total capital requirements for mine and infrastructure development are expected to reach about $64 million, including a $5 million allowance for working capital.

The Bathurst Norsemines Ltd. property in the Hackett River area, which is under option to Cominco Ltd., will undergo a feasibility study during 1976 by Wright Engineers at a cost of $100,000. This decision follows metallurgical testing, transportation and logistic studies and further diamond drilling during 1975. Cominco Ltd. has expended about $2 million to year-end 1975 on the property. Earlier it was agreed that Cominco could earn a 65 per cent interest in Bathurst Norsemines Ltd. by spending $6 million on exploration and development, and financing the property to production. Ore reserves in the Boot Lake zone, the East Cleaver Lake zone and the Main zone indicate more than 20 million tons, with ore in the three zones being open to extension both laterally and to depth.

Metal production

Production of refined primary zinc metal in Canada during 1975 was 470,622 tons compared with 469,884 tons in 1974. Nearly 80 per cent of refined production was in High Grade (HG) and Special High Grade (SHG) form, with the balance being Prime Western (PW) or Good Ordinary Brand (GOB) as it is known overseas. Collectively, Canadian zinc metal producers operated at 75 per cent capacity during 1975 owing to reduced demand for metal. In the same period, stocks of zinc metal held by producers rose from about 34,000 tons in 1974 to a peak of about 127,000 tons in August 1975, ending the year at about 109,000 tons. Metal production was distributed as shown in Table 9.

Metal production at Canadian Electrolytic Zinc declined to 117,700 tons of refined zinc in 1975 compared with 134,800 tons in 1974. Weak demand for metal resulted in a cutback in production and a four-week shutdown. Installation of plant and equipment to expand capacity to a rated 620 tons a day from 420 tons a day was nearing completion at year-end 1975. As of January 1, 1976 ownership of the expanded plant was changed to: Mattagami Lake Mines Limited, 51.67%; Noranda Mines Limited, 22.67%; Orchan Mines Limited, 15.83% and Kerr Addison Mines Limited, 9.83%.

Texasgulf Canada Ltd. operated its electrolytic zinc plant at 50 per cent of capacity during March, April and May and at 70 to 90 per cent of capacity from June through November, returning to full-capacity operation in December. Zinc metal production was 93,000 tons, compared to 107,900 tons in 1974. During 1975 maintenance work was carried out to put the plant in excellent condition to maintain capacity production when required.

The electrolytic zinc plant at Trail, B.C. owned by Cominco Ltd. produced 194,000 tons in 1975 compared with 162,000 tons in 1974. To maintain metal inventories at reasonable working levels the plant was shut down during August and operations have been at reduced rates since. During the year, sulphur-burning equipment was installed in the zinc plant to permit fertilizer manufacture independent of metallurgical operations. Also at Trail, a new 850-ton-a-day acid plant began operation as two older plants were shut down. Other modifications included a fume eliminator on the zinc stack.

The Flin Flon, Manitoba electrolytic zinc plant owned by Hudson Bay Mining and Smelting Co., Limited produced 65,117 tons in 1975 compared with 77,996 tons in 1974. Due to reduced sales, production was cut back to 70 per cent of capacity for part of the year.

During 1975 Brunswick Mining and Smelting Corporation initiated a feasibility study to build an integrated electrolytic zinc refinery at Belledune, New Brunswick. The study, which is expected to cost $1.0 million, will be concluded in 1976.

Metal consumption

Canadian consumption of primary zinc is estimated to be 117,000 tons in 1975 compared to 121,000 tons in 1974. Typically, usage is broken down into protective coatings, 49%; alloy for diecast parts, 21%; brass, 12%; and a general category including zinc oxide as the major component, 18%. The Zinc Institute Inc., reports that consumption was down in all market sectors in 1975, coincident with decreased activity in construction, and production of durable goods during the year. Galvanized sheet and diecastings experienced the largest decline although galvanizing after fabrication had a smaller decline than most markets. Many large consumers entered 1975 with high inventories of metal and purchased very little during the first six months. Consumer inventories remained at low levels during the balance of the year. During 1975, the Institute conducted a survey of the 59 Canadian diecasters to determine end usage of diecast parts, which indicated a market breakdown as follows: automotive components, 38.2%, most of which are exported to the United States; builders' hardware, 28.3%; electrical components, 11.4%; industrial-agricultural-commercial machinery, 5.5%; sound and television equipment, 1.3%; sporting goods and toys, 0.8%; scientific and professional equipment, 0.1% and miscellaneous industries, 6.3%. Automotive and electrical components and builders hardware accounted for nearly 80 per cent of all diecast parts produced in Canada. The major diecasting companies were Hudson Bay Diecasting Limited, Doehler Canada Limited, Albright Platers Ltd. and National Hardware Specialties Limited.

The protective coatings market, represented primarily by 41 galvanizing companies, includes the largest industrial consumers of zinc in Canada; The Steel Company of Canada, Limited and Dominion Foundries and Steel, Limited, which have continuous lines for the galvanizing of sheet steel. Of the 135 foundries in Canada that produce brass and other copper alloys, the four major companies that consume zinc metal are Noranda Manufacturing Ltd, The Canada Metal Company, Limited, Anaconda Copper and Brass Co., and Radcliff (Canada) Ltd. In the production of zinc oxide, the main producers are Zochem Limited, Pigment and Chemical Company Limited, and G.H. Chemicals Ltd.

World industry

Mine production. World mine production of zinc in 1975 was 4,931,600 tons zinc content, almost unchanged from the previous year. During the year 115,500 tons of new mine capacity came on stream outside Canada, partially offset by 22,000 tons in known closures. The capacity of new mines and expansions in 1975 were: Bleiberger Bergwerks Union at Bleiberg, Austria, 3,300 tpy; Société Minière et Metallurgique de Penarroya, S.A., at Saint Salvy, France, 23,100 tpy, and at Fedj Hassen, Tunisia, 6,600 tpy; Orkla Industrier A.s. at Orkla, Norway, 5,500 tpy; Asturiana de Zinc at Huelva, Spain, 7,700 tpy; Bolaget Vieille Montagne at Ammeberg, Sweden, 22,000 tpy; Tormex Mining Developers Limited in Guatemala, 11,000 tpy; Rosario Resources Corporation at Santa Barbara, Honduras, 5,500 tpy; Fresnillo Company at Zimapan, Mexico, 8,800 tpy; Rio Pallanga at Junin, Peru, 4,400 tpy; The Anaconda Company and ASARCO at Park City, Utah, U.S.A., 17,600 tpy. The known closure was Industrial Minera Mexico S.A. at Parral, Mexico, 22,000tpy.

Firm mine development outside Canada for the 1976-79 period totals 944,400 tons per year of new capacity and includes; Hellenic Chemical at Olympias, Greece, 19,800 tpy, 1976; Tara Exploration and Development Company Limited at Navan, Ireland, 231,-500 tpy, 1977; Exploracion Minera International (Espana) S.A. (Exminesa) at Rubiales, Spain, 73,900 tpy, 1977; Andaluza de Piritas Espanola at Aznacollar, Spain, 52,900 tpy, 1978; Boliden Aktiebolag at Stekenjokk, Sweden, 13,200 tpy, 1976; Beril Maden at Camardi, Turkey, 24,300 tpy, 1976; Cinkur at Zamanti, Turkey, 44,100 tpy, 1976; RMHK Trepica at Blagodat, Yugoslavia, 4,400 tpy, 1977, at Novo Brdo, Yugoslavia, 15,400 tpy, 1977, and at Lece, Yugoslavia, 4,400 tpy, 1977; Brskovo at Brskovo, Yugoslavia, 23,100 tpy, 1976; Energoinvest Corporation at Srebrenica, Yugoslavia, 7,700 tpy, 1977; Zletovo-Sasa at Sasa, Yugoslavia, 7,700 tpy, 1977; Sonarem at Kherzet-Youcef, Algeria, 12,100 tpy, 1978, and Kef-oum-Teboul, Algeria, 3,300 tpy, 1980.

The New Jersey Zinc Company at Potosi, Bolivia, 29,800 tpy, 1976; Metmig at Paracatu-Morro Agudo, Brazil, 38,600 tpy, 1978; Rosario Resources at Pueblo

Table 11. Western world zinc industry, production and consumption, 1975

	Mine Production	Metal Consumption	Metal Production	Metal Capacity[e]	Per cent Capacity Utilization
	(thousands of short tons primary zinc)				
Europe (EEC-EFTA[1])					
Austria	22.9	24.4	21.3	24.3	87.7
Belgium	—	104.3	240.6	367.0	65.6
Denmark	99.0	13.0	—	—	—
Finland	58.2	17.6	120.7	165.3	73.0
France	14.9	222.4	199.7	324.1	61.6
West Germany	148.0	325.7	325.0	467.4	69.5
Ireland	77.0	4.4	—	—	—
Italy	83.4	165.3	184.5	259.0	71.2
Netherlands	—	37.5	136.7	165.3	82.7
Norway	26.7	30.3	66.8	93.7	71.3
Portugal	1.3	13.2	—	—	—
Sweden	118.2	33.3	—	—	—
Switzerland	—	18.8	—	—	—
United Kingdom		229.9	58.9	99.2	59.4
Total	649.6	1,240.1	1,354.2	1,965.3	68.9
Europe (Other)					
Greece	22.0	13.2	—	—	—
Spain	92.3	101.1	145.1	154.3	94.0
Turkey	29.8	19.8	—	—	—
Yugoslavia	88.2	79.4	104.7	127.9	81.7
Total	232.3	213.5	249.8	282.2	88.5
Africa					
Algeria	25.4	10.6	33.1	33.1	100.0
Congo	5.5	—	—	—	—
Morocco	17.6	1.8	—	—	—
South Africa	119.0	72.0	70.2	93.7	74.9
Tunisia	6.6	0.9	—	—	—
Zaire	93.7	—	68.3	77.1	88.6
Zambia	73.3	1.5	53.8	70.5	76.3
Other	—	41.4	—	—	—
Total	341.1	128.2	225.4	274.4	82.1
Americas					
Canada	1,350.7	117.0	470.6	625.0	75.3
United States	518.2	924.5	471.0	690.0	68.3
Honduras	24.3	0.7	—	—	—
Mexico	276.7	66.1	153.2	217.2	70.5
Nicaragua	11.7	0.3	—	—	—
Argentina	47.4	46.3	43.7	56.2	77.8
Brazil	38.5	116.8	30.9	38.6	80.1
Bolivia	46.3	0.4	—	—	—
Chile	2.2	5.6	—	—	—
Columbia	1.1	8.8	—	—	—
Peru	438.7	8.9	70.8	80.5	88.0
Venezuela	—	18.7	—	—	—
Other	—	4.0	—	—	—
Total	2,755.8	1,318.1	1,240.2	1,707.5	72.6

Table 11. (concl'd)

	Mine Production	Metal Consumption	Metal Production	Metal Capacity	Per cent Capacity Utilization
	(thousands of short tons primary zinc)				
Asia					
Iran	44.0	11.0	–	–	–
India	24.0	110.2	32.0	41.9	76.4
Burma	6.6	0.3	–	–	–
Rep. of Korea	55.1	27.6	16.5	28.7	57.5
Philippines	6.6	12.1	–	–	–
Thailand	19.8	22.0	–	–	–
Japan	280.4	597.8	773.6	1,062.6	72.8
Other	14.3	91.7	–	–	–
Total	450.8	872.7	822.1	1,133.2	72.5
Oceania					
Australia	502.0	85.2	216.9	347.2	62.5
New Zealand	–	17.6	–	–	–
Total	502.0	102.8	216.9	347.2	62.5
Total Western World	4,931.6	3,875.4	4,108.6	5,709.9	72.0%

Sources: International Lead and Zinc Study Group. Statistics Canada.
[e] Estimated by the Mineral Development Sector, Department of Energy, Mines and Resources, Ottawa.
[1] European Economic Community (common market) – European Free Trade Association.

Viejo, Dominican Republic, 16,500 tpy, 1976; Industrial Minera Mexico at Taxco, Mexico, 24,300 tpy, 1976, at Santa Barbara, Mexico, 11,000 tpy, 1979, at Charcas, Mexico, 7,700 tpy, 1976, at Velardena Durango, Mexico, 12,100 tpy, 1978, and at Tecolote Sonora, Mexico, 8,800 tpy, 1978; Madrigal at Arequipe, Peru, 4,400 tpy, 1976; Milpo at Pasco, Peru, 14,300 tpy, 1976; San Ignacio at Junin, Peru, 16,500 tpy, 1976; El Brocal at Pasco, Peru, 12,100 tpy, 1976; New Jersey Zinc and Union Miniere Explorations and Mining Corporation Limited in Tennessee, U.S.A., Elmwood II, 22,000 tpy, 1978, and Elmwood South, 27,600 tpy, 1979; Hindustan Zinc Co. at Zarwar Rajasthan 22,000 tpy, 1976, and at Rajpura Rajasthan, 47,400 tpy, 1978; Calcimine at Zanjan, Iran, 44,100 tpy, 1977; Bafq Mining at Yazd, Iran, 14,300 tpy, 1977; and Bama Mining at Isfahan, Iran, 43,000 tpy, 1977.

In Canada, new and expansion mine capacity that will come into production during the 1976-1979 period totals 175,200 tons per year and includes: Heath Steele at Little River, N.B., 15,400 tpy, 1976; Nanisivik Mines at Strathcona Sound, Baffin Island, N.W.T., 66,100 tpy, 1976; Noranda at Magusi River, Que., 13,200 tpy, 1978; Lemoine Mines at Chibougamau, Que., 11,000 tpy, 1976; Mattagami Mines – Lyon Lake Division in the Sturgeon Lake area, Ont., 27,600 tpy, 1978; Northair Mines at Brandywine Falls, B.C., 3,300 tpy, 1976; and Brunswick Mining and Smelting at Bathrust, N.B., 38,600 tpy, 1979.

Metal Production. World primary zinc metal production in 1975 declined 700,000 tons to 4,108,600 tons as consumption collapsed. On average, zinc plants operated at 72 per cent of rated capacity compared with 88.7 per cent in 1974. Zinc plants in the industrialized nations such as the United States, 68.3%; EEC and EFTA countries, 68.9% and Japan, 72.8%, were effected the most. A few metal exporting countries, despite market conditions, actually increased production from last year. These countries were Finland, The Netherlands, Spain, Yugoslavia and Algeria.

Additional metal capacity from new refineries and expansions outside Canada in 1975 totalled 325,300 tons from: Outokumpu Oy at Kokkola, Finland, 60,100 tpy, E.*; Asturienne at Auby, France, 110,000 tpy, E.; Asturiana de Zinc at Aviles, Spain, 104,700 tpy, E.; Zincor at Springs, South Africa, 22,000 tpy, E.; and Electrolytic Zinc Company of Australia Ltd. at Risdon, Australia, 22,000 tpy, E. Plant closures consisted of Asturienne at Auby, France, 88,200 tpy, V.R.; and ASARCO at Amarillo, Texas, U.S.A., 49,600 tpy, H.R.

Firm zinc plant construction outside Canada scheduled for completion during the 1976-79 period will add 869,700 tons per year of new capacity as follows: Bleiberger Bergwerks Union at Gailitz, Austria, 5,500 tpy, 1977, E.; Pertusola at Crotone, Italy, 44,100 tpy, 1978, E.; Det Norske Zink at Odda, Norway, 16,500 tpy, 1977, E.; Asturiana de Zinc at Aviles, Spain, 77,200 tpy, 1977, E.; Espanola del Zinc at Cartagena, Spain, 33,100 tpy, 1976, E.; Cinko-Kursun Metal Sandyii AS at Incesu, Turkey, 44,100 tpy, 1976 E.; Zorka at Sabac, Yugoslavia, 16,500 tpy, 1978, E.; RMHK Trepica at Trepica, Yugoslavia, 44,100 tpy, 1979, E.; Mineira de Metais at Tres Marias, Brazil, 14,300 tpy, 1976, E.; Paraibuna de Metais at Juiz de Fora, Brazil, 33,100 tpy, 1978, E.; Metmig at Paracatu-Morro Agudo, Brazil, 38,600 tpy, 1978, E.; Industrial Minera Mexico at San Luis Potosi, Mexico, 115,700 tpy, 1977, E.; Minero Peru near Lima, Peru, 110,200 tpy, 1978, E.; Centromin at La Oroya, Peru, 68,300 tpy, 1976, E.; National Zinc Co. at Bartlesville, Okla., U.S.A., 57,300 tpy, 1976, E.; New Jersey Zinc and Union Miniere at Clarksville, Tenn., U.S.A., 88,200 tpy, 1979, E.; Hindustan Zinc at Vishakhpatnam, 33,100 tpy, 1976, E. and Debari, 29,800 tpy, 1976, E. in India. Closures during the same period are limited to National Zinc at Bartlesville, Okla., U.S.A., 49,600 tpy, 1976, H.R.

World Consumption. World consumption of primary zinc metal declined 1,200,000 tons to 3,875,400 tons in 1975. The decline was widespread, and almost without exception affected every country in the western world. As in the case of metal production, the industrialized nations were affected most, with 1975 consumption being only 68.7% of the 1974 level in the United States, 72.4% of the 1974 level in the EEC and EFTA countries, and 79.9% of the 1974 level in Japan.

Zinc uses

Zinc is used to galvanize steel and to make castings, alloys, sheet, zinc oxide and other compounds.

In galvanizing, zinc is applied as an impervious, corrosion resistant coating to iron and steel products to prevent rust. Galvanized sheet is used in industrial, agricultural and residential construction, for guard rails, culverts and signs in road construction, and for rocker panels and other vulnerable parts of automobiles. Galvanized reinforcing rods are used in the construction industry, and galvanized structural members are employed in bridge construction to save on painting and maintenance costs. Wire, pipe and numerous other articles are galvanized in instances where protection is required.

Consumption of galvanized sheet per automobile may increase slightly due to the availability of one-side galvanized sheet which allows for a higher welding productivity.

*Plant type: E., electrolytic retort; V.R. vertical retort; H.R., horizontal retort.

Die castings made of zinc-base alloys are used in the automotive industry for such parts as grilles, headlight and tailight assemblies, fender extensions, door and window hardware, carburetors and fuel pumps.

Zinc-base die castings are used as components in household appliances such as washing machines and refrigerators, and in plumbing and hardware supplies. The alloys most commonly used for die castings are made of special high-grade zinc (99.99 per cent or higher) to which is added 4 per cent aluminum, 0.04 per cent magnesium and up to 1 per cent copper. A new application which holds promise is superplastic zinc alloy (SPZ). It is a material containing 78 to 80 per cent zinc and 20 to 22 per cent aluminum, which behaves like a metal at normal temperatures and like a plastic when heated to just over 500°F for forming. It has excellent pressure-vacuum forming characteristics with excellent deep-drawing and elongation characteristics. It has very good electrical conductivity and is highly corrosion-resistant. It will take electroplating or painting. Principally because of its ductility, it is called a superplastic alloy, and will be used to manufacture pressed parts for the automobile and appliance industry. Parts made of superplastic zinc can be vacuum-formed from sheet, when hot, with minimal energy and using very low-cost moulds.

Brass, a copper — zinc alloy containing as much as 40 per cent zinc, has many applications in the form of sheets and strips, tubes, wire, rods, castings and extruded shapes. Rolled zinc is used in Canada mainly for making dry-cell batteries in which zinc serves both as the negative pole of the cell and as the container. In Europe, rolled zinc is a popular roofing and roof-flashing material. Other uses of rolled zinc are terrazzo strip and anticorrosion plates for boilers, dock pilings and ships' hulls. Zinc, in the form of 0.2 to 0.3 micron-size particles of zinc oxide (83 per cent zinc content), is finding increasing use as the major constituent of the paper coating for coated paper electrostatic copies. Demand for zinc for this application is expected to grow at a faster rate than for any other over the next few years. Zinc oxide is also used in compounding rubber and in making rayon yarn, ceramic materials, inks, matches, and many other commodities.

Weather-resistant paints based on zinc oxide and zinc dust provide one of the most effective and durable protective coatings on outside surfaces, especially metallic. A new application is a two-coat paint system known as *Zincrometal* that can be hot-rolled on coiled steel. It is applied on a chromium-base coating. This system is reported to have corrosion resistance similar to galvanized steel, and could replace it in some applications. It has, however, important limitations, since tests show that it gives little if any sacrificial protection on scratched surfaces or cut edges. Nevertheless, its use is forecast to expand in the automotive industry. However, it may not be as a substitution for galvanized sheet but as an addition to its use.

Table 12. Forecast of Capacities of Western World zinc plants, 1974-1980

		Zinc Plant		Estimated Capacity[e]			Expected Capacity[e]			
		Location	Type[1]	1974	1975	1976	1977	1978	1979	1980
				(thousands of metric tons)						
America				1,508	1,549	1,632	1,655	1,770	1,960	2,301
United States										
	AMAX	Sauget, Ill.	E	73	73	73	73	73	73	73
	ASARCO	Amarillo, Tex.	HR	50	21	—	—	—	—	—
	ASARCO	Corpus Christi, Tex	E	95	115	115	115	115	115	115
	ASARCO	Stephensport, Kty.[2]	E	—	—	—	—	—	—	163
	Bunker Hill	Kellogg, Ida.	E	96	96	96	96	96	96	96
	National Zinc	Bartlesville, Okla.	HR (E1976)	41	41	50	52	52	52	52
	New Jersey Zinc	Palmerton, Pa.	VR	80	80	80	80	80	80	80
	New Jersey Zinc	Clarksville, Tenn.[3]	E	—	—	—	—	—	40	80
	St. Joe Minerals	Monaca, Pa.[4]	ET	200	200	200	200	200	200	200
				635	626	614	616	616	656	859
Canada										
	Cominco	Trail, B.C.	E	244	254	264	273	273	273	273
	Hudson Bay M. & S.	Flin Flon, Man.	E	73	73	73	73	73	73	73
	C.E. Zinc	Valleyfield, Que.	E	132	132	204	20 4	204	204	204
	Texasgulf	Timmins, Ont.	E	108	108	108	108	108	108	136
	Brunswick M. & S.	Belledune, N.B.[5]	E	—	—	—	—	—	—	100
				557	567	649	658	658	658	786
Mexico										
	Ind. Minera Mexico	Rosita[6]	HR	62	62	62	62	—	—	—
	Ind. Minera Mexico	San Luis Potosi	E	—	—	—	—	75	110	110
	Zincamex	Saltillo	HR	30	30	30	30	30	30	30
	Ind. Penoles	Torreon	E	65	105	105	105	105	105	105
				157	197	197	197	210	245	245
Argentina										
	Sulfacid	Borghi	E	26	26	26	26	26	26	26
	Cie Metallurgia Austral	Comodoro	ET	16	16	16	16	16	16	16
	Meteor	Zarate	E	9	9	9	9	9	9	9
				51	51	51	51	51	51	51

Table 12. (cont'd)

		Zinc Plant		Estimated Capacity[e]			Expected Capacity[e]			
		Location	Type[1]	1974	1975	1976	1977	1978	1979	1980
				(thousands of metric tons)						
Brazil										
	Cia Ind. E. Mercantil Inga	Itaguai	E	10	10	10	10	10	10	10
	Cia Mineira De Metais	Tres Marias	E	25	25	38	50	50	50	50
	Metmig	Paracatu	E	—	—	—	—	15	35	35
	Paraibuna De Metais	Juiz De Fora	E	—	—	—	—	15	30	30
				35	35	48	60	90	125	125
Peru										
	Centromin	La Oroya	E	73	73	73	73	95	115	135
	Minero Peru	Cajamarquilla	E	—	—	—	—	50	100	100
				73	73	73	73	145	225	235
Europe (EEC and Others)				1,946	2,034	2,139	2,289	2,324	2,349	2,374
Europe (EEC only)				1,508	1,526	1,591	1,611	1,631	1,631	1,631
Belgium										
	Hoboken Overpelt	Overpelt	VR (E1975)	88	100	100	100	100	100	100
	Vieille Montagne S.A.	Balen	E	168	168	168	168	168	168	168
	Soc. Prayon	Ehein	E	65	65	65	65	65	65	65
				321	333	333	333	333	333	333
France										
	Vieille Montagne S.A.	Viviez	E	94	94	94	94	94	94	94
	Vieille Montagne S.A.	Creil	HR	9	—	—	—	—	—	—
	Penarroya S.A.	Noyelles Godault	ISP	105	105	105	105	105	105	105
	Cie. Royale Asturienne	Auby	VR (E1975)	90	95	100	100	100	100	100
				298	294	299	299	299	299	299

Table 12 (cont'd)

		Zinc Plant		Estimated Capacity[e]			Expected Capacity[e]			
		Location	Type[1]	1974	1975	1976	1977	1978	1979	1980
				(thousands of metric tons)						
West Germany										
	Duisburger Kupferhutte	Duisburg	E	10	10	10	10	10	10	10
	Metall. (Berzelius)	Duisburg	ISP	80	80	80	80	80	80	80
	Metall. (Ruhr Zinc)	Datteln	E	130	130	165	165	165	165	165
	Preussag	Harlingerode	VR	94	94	94	94	94	94	94
	Preussag Weser Zinc	Nordenham	E	110	110	110	110	110	110	110
				424	424	459	459	459	459	459
Italy										
	Soc. Pertusola	Crotone	E	90	90	90	110	130	130	130
	Ammi	Bergano	E	35	35	35	35	35	35	35
	Ammi	Monteponi	E	15	15	15	15	15	15	15
	Ammi	Porto Marghera	E	45	45	45	45	45	45	45
	Ammi Sarda	Porto Vesme	ISP	50	50	75	75	75	75	75
				235	235	260	280	300	300	300
Netherlands										
	Kemp. Zinc de la Campine	Budel	E	20	—	—	—	—	—	—
	Budelco	Budel	E	120	150	150	150	150	150	150
				140	150	150	150	150	150	150
United Kingdom										
	Commonwealth Smelting	Avonmouth	ISP	90	90	90	90	90	90	90
Europe (others)				438	513	548	678	693	718	743
Austria										
	Bleiberger Bergwerks	Gailitz	E	17	22	22	22	22	22	22
Finland										
	Outokumpu Oy	Kokkola	E	90	150	150	150	150	150	150

Table 12. (cont'd)

		Zinc Plant		Estimated Capacity[e]			Expected Capacity[e]			
		Location	Type[1]	1974	1975	1976	1977	1978	1979	1980
				(thousands of metric tons)						
Europe (others) (cont'd)										
Norway										
	Det Norske	Eitrheim	E	85	85	85	100	100	100	100
Spain										
	Asturiana De Zinc	Aviles	E	105	110	135	200	200	200	200
	Espanol Del Zinc	Cartagena	E	30	30	30	60	60	60	80
				135	140	165	260	260	260	280
Turkey										
	Cinko-Kursan	Incesu	E	—	—	10	30	40	40	40
Yugoslavia										
	Hemijska Ind. Zorka	Sabac	E	25	25	25	25	30	35	40
	R.M.H.K. Trepca	Zvencan	E	36	36	36	36	36	56	76
	Top. Za. Cink I. Zletovo	Titov Veles	ISP	50	55	55	55	55	55	55
				111	116	116	116	121	146	171
Africa				199	249	259	259	259	259	259
Algeria										
	Soc. Nat. de Siderurgie	Ghazaouet	E	—	30	40	40	40	40	40
South Africa										
	Zinc Corporation	Vogelstuisbuilt	E	65	85	85	85	85	85	85
Zaire										
	Soc. Met. Katangese	Kolwezi	E	70	70	70	70	70	70	70
Zambia										
	Nchanga Cons. Copper	Broken Hill	ISP	34	34	34	34	34	34	34
	Nchanga Cons. Copper	Kabwe	E	30	30	30	30	30	30	30
				64	64	64	64	64	64	64

Table 12. (cont'd)

		Zinc Plant		Estimated Capacity[e]			Expected Capacity[e]			
		Location	Type[1]	1974	1975	1976	1977	1978	1979	1980
				(thousands of metric tons)						
Oceania				315	315	315	315	315	315	315
Australia										
	Electrolytic Zinc	Risdon	E	200	200	200	200	200	200	200
	Sulphide Corp.	Corkle Creek	ISP	70	70	70	70	70	70	70
	Broken Hill Assoc. Smelters	Port Pirie	E	45	45	45	45	45	45	45
				315	315	315	315	315	315	315
Asia				951	1,028	1,053	1,067	1,092	1,117	1,117
India										
	Hindustan Zinc	Debari	E	18	18	18	27	2 7	27	27
	Hindustan Zinc	Vishakhpatnam	E	—	—	25	30	30	30	30
	Cominco-Binani	Kerala	E	20	20	20	20	20	20	20
				38	38	63	77	77	77	77
Japan										
	Akita Co.	Iijima	E	90	156	156	156	156	156	156
	Hachinohe S. Co.	Hachinohe	ISP	76	76	76	76	76	76	76
	Mitsubishi M. Corp.	Akita	E	97	97	97	97	97	97	97
	Mitsubishi M. Corp.	Hosokura	E	20	20	20	20	20	20	20
	Mitsui M. & S.	Hikoshima	E	66	66	66	66	66	66	66
	Mitsui M. & S.	Kamioka	E	61	61	61	61	61	61	61
	Mitsui M. & S.	Miike	E	20	20	20	20	20	20	20
	Mitsui M. & S.	Miike	VR	118	118	118	118	118	118	118
	Nippon M. Co.	Mikkaichi	ET	120	120	120	120	120	120	120
	Nisso S. Co.	Aizu	E	31	31	31	31	31	31	31
	Sumiko ISP Co.	Harima	ISP	60	60	60	60	60	60	60
	Toho Zinc Co.	Annaka	E	139	139	139	139	139	139	139
				898	964	964	964	964	964	964

Table 12. (concl'd)

		Zinc Plant		Estimated Capacity[e]			Expected Capacity[e]			
		Location	Type[1]	1974	1975	1976	1977	1978	1979	1980
Rep. of Korea										
	Korea Zinc Co.	Onsan	E	—	—	—	—	25	50	50
	Tong Shin Chemical	Seoul	E	6	6	6	6	6	6	6
	Eiho Shoji Co.	Sekiho	E	9	20	20	20	20	20	20
				15	26	26	26	51	76	76
Total, Western World				4,919	5,180	5,398	5,585	5,760	6,000	6,366

[1]Type of zinc plant is abbreviated as follows E — Electrolytic, HR — Horizontal Retort, ISP — Imperial Smelting Process, VR — Vertical Retort, ET — Electrothermic. [2]Anticipated construction of agreed joint venture with M-I-M Holdings Limited. [3]Announced joint venture with Union Minière S.A. [4]Total slab capacity 285,000 metric tons including 40,000-metric-ton expansion in 1973-76. However, 85,000 tons devoted to oxide production. [5]Anticipated construction of integrated refinery currently in feasibility stage.
[6]Anticipated closure associated with new 110,000 metric ton plant at San Luis Potosi commencing 1978.
[e]Estimated by the Mineral Development Sector, Department of Energy, Mines and Resources, Ottawa; — Nil.

Table 13. Canadian producers' zinc prices in 1975

	Prime Western	High Grade	Special High Grade	Prime Western (controlled lead)	Continuous Galvinizing Grade
	(cents per pound of primary zinc metal)				
Canada (Cdn.¢)	37.0	37.0	37.5	37.25	37.5
United States (U.S.¢)	39.0	39.0	39.5	39.25	39.25

Zinc dust, which is a finely divided form of zinc metal, is used in the process of printing and dyeing textiles, in zinc-rich paints, in purifying fats and precipitating gold and silver from cyanide solutions. The more important industrial compounds of zinc are zinc sulphide, which in combination with barium sulphate forms the pigment lithopone; zinc sulphate, used in rayon fibre manufacture; and zinc chloride, a wood preservative.

The International Lead Zinc Research Organization, Inc. (ILZRO) is the main body assisting industry to find new uses for lead and zinc. Promotion and advertising of new zinc products and processes is carried on by the Zinc Institute, Inc. which opened a branch office in Toronto in 1968. The development of thin-walled diecastings and of improved zinc-based diecasting alloys has done much to expand the use of zinc as a diecasting metal in competition with alternative materials such as aluminum and plastics.

Prices

In North America, where 85 per cent of all Canadian primary zinc metal production is marketed, prices for various grades of zinc metal sold by Canadian producers remained unchanged from 1974 throughout the entire year. Metal was sold on a delivered basis, including duty for United States destination as shown in Table 13.

Outside North America, market prices for metal covering the balance of Canadian primary zinc metal production were subject to some erosion during the course of the year 1975, despite appearances to the contrary. Traditionally, zinc metal exports outside North America have been sold using a £ sterling quotation, which Canadian primary metal producers, as well as other international primary producers and marketers of zinc metal, adopted. In 1975 the £ sterling continued a long-term trend of erosion against other currencies, thereby reducing the price of zinc metal in the domestic currency of producers outside the United Kingdom. In terms of U.S. dollars, the rate of exchange for the £ sterling declined from a monthly average high of $2.418 in March to $2.022 in December. During the period January to September, Canadian and other producers sold Good Ordinary Brand (GOB) zinc metal outside North America at £360 per metric ton, however, the U.S.-dollar-realized price for such metal fluctuated with exchange rates, and over-all, declined from a monthly average high of 39.5¢ per pound in March to a low of 34.0¢ per pound in September. On October 10, 1975 Cominco Ltd. raised its base price for GOB metal from £360 to £390 per metric ton. Enough additional Canadian, Australian, and European producers followed Cominco's lead the following week that the *Metal Bulletin* which is published in London, England changed the "GOB Producer basis" quotation to the new level on October 16, 1975. Effectively on that date all zinc in concentrate sold by Canadian and other mine producers to refineries outside North America was paid for at £390 per metric ton, thereby establishing the new international price level for good ordinary brand zinc. Based upon an average U.S. dollar exchange rate for the £ sterling in September of $2.083, the equivalent price in U.S. currency was 36.85¢ per pound. Continued erosion in the £ sterling to year-end 1975 and beyond, as measured by the forward market for currency, resulted in the Electrolytic Zinc Company of Australasia Ltd. declaring a price increase for good ordinary brand metal from £390 metric ton to $795 per metric ton in U.S. currency effective November 24, 1975. Sufficient additional metal producers followed this lead during December to cause the Metal Bulletin to raise the "GOB Producer basis" quotation to the new level on January 2, 1976, thus establishing the new price for zinc in concentrate outside North America. The new price was 36.06¢ per pound. Delivery of GOB metal is now considered to be cif* world port of discharge which excludes import duty and inland freight to the buyers' works.

Normal premiums for high-grade (min. 99.95% purity) and special-high-grade (min. 99.99% purity) zinc metal outside North America remained at £4.50 and £8.00 per metric ton respectively throughout 1975; however, for certain suppliers the premiums eroded substantially during the year, reflecting declining market conditions. For high-grade zinc the premium to certain suppliers declined from £12 per metric ton to £5.00 by January 27, 1975: By September 26, 1975, it had dropped to the £4.00 – £4.50 range and by October 16, 1975 was eliminated. For special high grade, during the same time frame, the premium successively declined from £16 per metric ton to the £8.00 – £10.00 range, to the £7.00 – £8.00 range and finally to the zero – £4.50 range.

The price for prompt zinc (min. 98 per cent purity) on the London Metal Exchange remained at a discount

*Cost Insurance Freight.

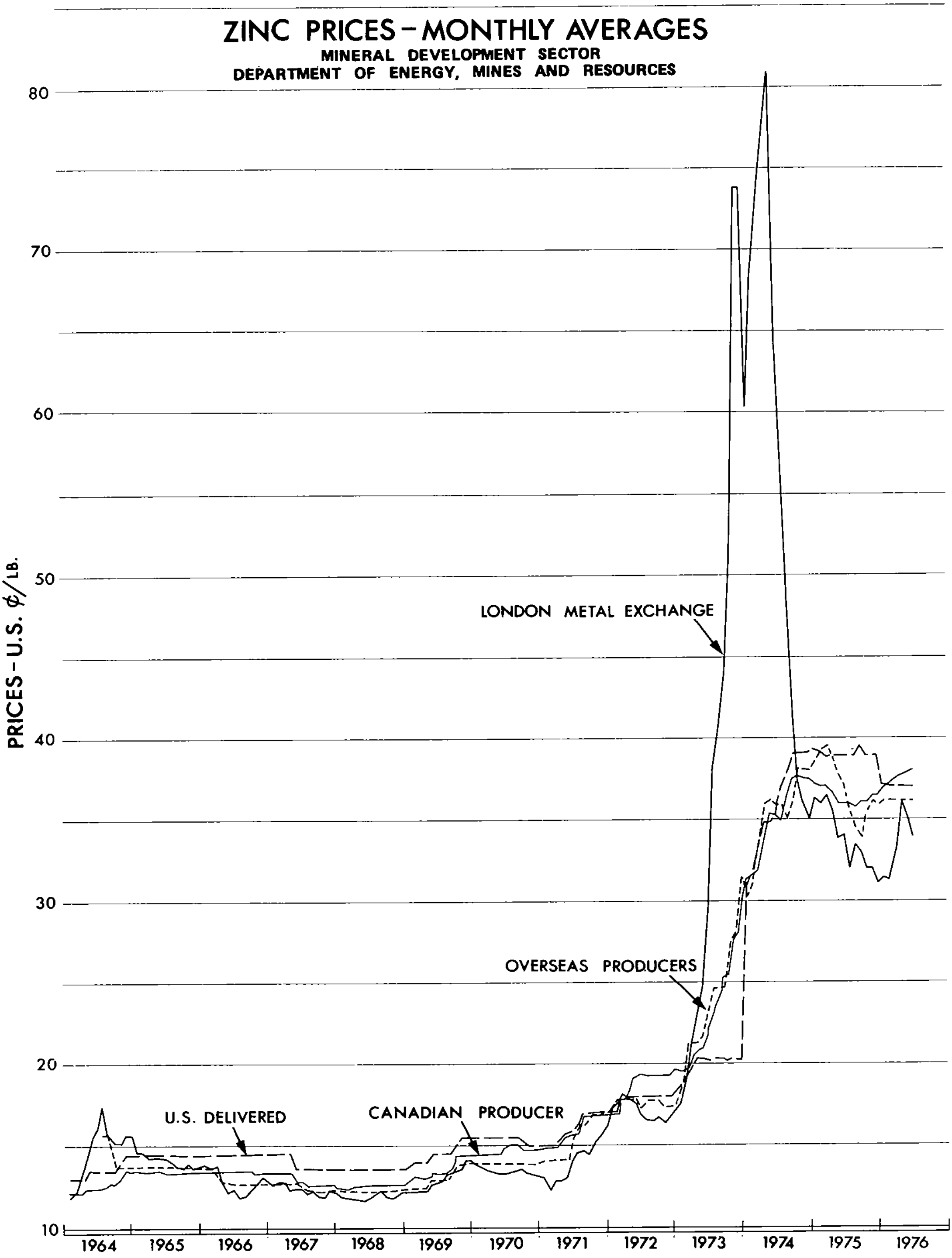

ZINC PRICES - MONTHLY AVERAGES
MINERAL DEVELOPMENT SECTOR
DEPARTMENT OF ENERGY, MINES AND RESOURCES
PRICES - U.S. ¢/LB.
80
70
60
50
40
30
20
10
LONDON METAL EXCHANGE
OVERSEAS PRODUCERS
U.S. DELIVERED
CANADIAN PRODUCER
1964
1965
1966
1967
1968
1969
1970
1971
1972
1973
1974
1975
1976

Table 14. 1975 International zinc metal prices

Month	Producers Canada	Producers U.S.	Producers Outside N. America	L.M.E. Prompt	Producers Canada	Producers U.S.	Producers Outside N. America	L.M.E. Prompt
	Cdn.¢/lb.	U.S.¢/lb.	£/metric ton	£/metric ton	Comparative quotations	U.S. cents per lb[1].		
	(good ordinary brand or prime western)							
January	37.0	39.2	360.0	338.2	37.2	39.2	38.6	36.2
February	37.0	39.1	360.0	331.4	37.0	39.1	39.1	36.0
March	37.0	38.8	360.0	332.1	37.0	38.8	39.5	36.4
April	37.0	38.8	360.0	330.1	36.6	38.8	38.7	35.5
May	37.0	38.8	360.0	321.9	36.0	38.8	37.9	33.9
June	37.0	38.8	360.0	329.2	36.0	38.8	37.2	34.0
July	37.0	38.8	360.0	323.9	35.9	38.8	35.7	32.1
August	37.0	38.8	360.0	348.4	35.7	38.8	34.5	33.4
September	37.0	39.4	360.0	347.2	36.1	39.4	34.0	32.8
October	37.0	38.8	379.6	343.1	36.1	38.8	35.4	32.0
November	37.0	38.8	390.0	344.1	36.5	38.8	36.2	32.0
December	37.0	38.8	390.0	339.1	36.5	38.8	35.8	31.1
1975 average	37.0	38.9	366.6	335.7	36.4	38.9	36.9	33.8
1974 average	34.3	35.2	332.2	528.7	35.0	35.2	35.3	56.3

Source: International Lead Zinc Study Group Bulletin.
[1]U.S. cents comparative quotations prepared by the Mineral Development Sector, Department of Energy, Mines and Resources, Ottawa, using monthly average exchange rates published by *Metals Week* in the United States.

to prices quoted by producers in Canada, the United States, and outside North America. The Sterling quotations fluctuated between £321.9 and £348.4 per metric ton on a monthly average basis and opened and closed the year at £338.2 and £339.1 per metric ton respectively. The $ U.S. equivalent quotations are more illustrative in depicting an almost steady decline from 36.2¢ in January to 31.1¢ in December. It is generally-accepted knowledge that the London Metal Exchange (LME) as a source of metal represents about 5 per cent of western world consumption. Delivery of LME metal is taken at LME warehouses in the United Kingdom and on the continent.

Comparative prices for prime western and good ordinary brand metal in various international markets during 1975 are set out in Table 14, and during the period 1964-1975, on the preceding figure.

World outlook

Demand for metal can be expected to recover to the 1974 level by 1977; however, continued growth in demand thereafter can reasonably be expected to be below the traditional compound growth rate of about 4.6 per cent since 1960. Continuing reduced consumption by the U.S. automotive industry between 1975 and 1985 in response to higher performance standards in relation to gasoline consumption, which will inevitably lead to smaller and lighter automobiles, will be a major negative factor. Similarly, some decline in the historical growth rate of 9.3 per cent in Japan towards the lower growth rates experienced by the other major industrialized nations such as the United States (3.1 per cent) or the European Economic Community (2.7 per cent) can also be expected. Metal producers should see some additional improvement in the short term through stock-building by consumers and possibly several national governments; however, the planned 870,000 tons of new zinc plant capacity coming into production during the 1976-1979 period could hold plant utilization to about 80 per cent of capacity. It is also possible that some of this new capacity will actually be deferred to 1980-81.

Mine production in 1975 did not react susbtantially to the downturn in 1975 demand. However, many mines can be expected to cut back concentrate production in 1976, which will reduce stockpiles at mines and smelters. New mine capacity of about 1,100,000 tons during the 1976-79 period is expected to come into production. However, an estimated 400,000 tons could possibly be expected to offset declining existing reserves and ore grades, leaving about 600,000 tons of net recoverable new capacity. This would represent, at an 85 per cent operating level, about 500,000 tons of new zinc-in-concentrate production. This level of production growth is likely to be consistent with growth in western world consumption, but short of growth in new zinc plant capacity. Accordingly, some improvement in the 1975-1976 level of concentrate financial terms to mine producers would appear likely in the near-term to cover deliveries of concentrate in the period 1977-1979. This may lead to a substantial improvement in the level of metal prices in the 1977-1979 period; however, it is difficult to foresee metal rising higher than the 39 to 40¢-per-pound range achieved in late 1974 and early 1975 before late in 1977, particularly in markets outside North America. Earlier-than-anticipated recovery for both concentrate and metal markets could well depend upon increased western trade with centrally-planned economies in the eastern countries, particularly if the high concentrate export levels in 1974 and 1975 are indicative of expanded requirements in these countries over the next few years.

Tariffs

The following tariffs apply for zinc in its various forms

Canada

Item no.		GSP[1]	British Preferential	GATT[2]	General
32900-1	Zinc in ores and concentrates	Free	Free	Free	Free
34505-1	Zinc spelter, zinc and zinc alloys containing more than 10% by weight of other metal or metals, in the form of pigs, slabs, dust or granules.	Free	Free	Free	2¢/lb.
34500-1	Zinc dross and zinc scrap for remelting, or for processing into zinc dust.	Free	Free	Free	10%
35800-1	Zinc anodes	Free	Free	Free	10%

United States

USTS No.		GSP	GATT
602.20	Zinc ores and concentrates, on zinc content	0.67¢/lb.(susp)[3]	0.67¢/lb.(susp)
	Unwrought zinc		
626.02	Unalloyed	0.7¢/lb	0.7¢/lb.
626.04	Alloys of zinc	19%	19%
626.10	Zinc waste and scrap	0.75c/lb(susp)	0.75c/lb(susp)

EEC

BTN No.		GSP	GATT
26.01	Zinc ore and concentrates	Free	Free
79.01	Unwrought zinc	Free	4.5%
	Zinc waste and scrap	Free	Free

Japan

BTN No.		GSP	GATT
26.01	Zinc ores and concentrates	Free	Free
79.01	Unwrought zinc, 97% zinc	8 Yen/kg	8 Yen/kg
	Zinc waste and scrap	Free	2.5%

GSP[1] — Generalized System of Preferences extended to all or most developing countries.
GATT[2] — General Agreement on Tariffs and Trade (most favoured nation treatment).
(susp)[3] — suspended.

View of the Texasgulf copper, zinc, lead and silver open-pit mine at the Kidd Creek complex in Timmins, Ontario.
(Photo by Herb Nott & Co. Ltd.)

Statistical Summary

This chapter of the Yearbook is a statistical summary of Canadian mining and related activities. The statistical information is as comprehensive as possible given the availability of data.

The summary is divided into nine sections, each containing a number of statistical tables. The sections are preceded by a list of tables by section, number and title and by a table entitled Canada, general economic indicators, 1961-75.

The sources of Canadian Mineral Industry statistics are Statistics Canada, other federal departments and agencies, provincial governments and company annual reports. International mineral statistics are derived from U.S. Bureau of Mines publications, *American Bureau of Metal Statistics, World Bureau of Metal Statistics, Metals Week, Engineering and Mining Journal.* United Nations and the Organization for Economic Cooperation and Development.

Where applicable, an explanation of a concept or a term is contained in the footnote to a statistical table. If further information is required, the source of the information should be consulted.

The statistical summary was prepared by J.T. Brennan and Staff, Statistics Section, Mineral Development Sector.

STATISTICAL TABLES

SECTION 6 EMPLOYMENT, SALARIES AND WAGES

SECTION 7 MINING, EXPLORATION AND DRILLING

SECTION 8 TRANSPORTATION

SECTION 9 INVESTMENT AND FINANCE

		1961	1962	1963	1964	1965
Gross national product, current dollars	$ million	39,646	42,927	45,978	50,280	55,364
Gross national product, constant dollars (1971=100)	,,	54,741	58,475	61,487	65,610	69,981
Value of manufacturing industry shipments	,,	24,428	26,713	28,741	31,560	33,889
Value of mineral production	,,	2,603	2,881	3,027	3,365	3,715
Merchandise exports	,,	5,755	6,179	6,799	8,094	8,525
Merchandise imports	,,	5,769	6,258	6,558	7,488[r]	8,633
Balance of trade, current account	,,	−928[r]	−830	−521	−424	−1,130
Corporation profits before taxes	,,	4,066[r]	4,450[r]	4,932[r]	5,841[r]	6,318[r]
Capital investment, current dollars	,,	8,292	8,769	9,398	10,980	12,935
Capital investment, constant dollars (1971=100)	,,	11,672	12,159	12,653	14,259	15,944
Population	000	18,238	18,583	18,931	19,290	19,644
Labour force	,,	6,521	6,615	6,748	6,933	7,141
Employed	,,	6,055	6,225	6,375	6,609	6,862
Unemployed	,,	466	390	374	324	280
Unemployment rate	%	7.1	5.9	5.5	4.7	3.9
Employment index	1961=100	100.0	102.2	104.3[r]	108.2	114.3
Labour income	$ million	20,399	21,816	23,262	25,367	28,201
Industrial production index	1971=100	54.3	58.8	62.5	68.7	74.4
Manufacturing production index	,,	55.0	60.0	64.0	70.1	76.4
Mining production index	,,	54.7	58.1	61.3	68.9	72.1
Index of real domestic product	,,	57.1	61.1	64.4	68.8	73.7
General wholesale price index	1935-39=100	233.3	240.0	244.6	245.4	250.3
Consumer price index	1971=100	75.0	75.9	77.2	78.6	80.5

[p]Preliminary; [r]Revised.

indicators, 1961-75

1966	1967	1968	1969	1970	1971	1972	1973	1974	1975[p]
61,828	66,409	72,586	79,815	85,685	94,115	104,669	122,582	144,616	161,132
74,844	77,344	81,864	86,225	88,390	94,115	99,680	106,845	110,293	110,975
37,303	38,955	41,997	45,110	45,991	50,274	56,246	66,758[r]	82,459	87,598
3,981	4,381	4,722	4,734	5,722	5,963	6,408[r]	8,370[r]	11,746	13,404
10,071	11,112	13,270	14,498	16,401	17,397	19,671[r]	24,836[r]	31,412	32,325
10,072[r]	10,873[r]	12,358[r]	14,130	13,952	15,618[r]	18,669	23,324[r]	31,639	34,635
−1,162	−499	−97	−917	+1,106	+431	−386	+96	−1,492	−4,965
6,714[r]	6,823[r]	7,742[r]	8,294[r]	7,699[r]	8,681[r]	10,799[r]	15,032[r]	18,800	18,587
15,088	15,348	15,455	16,927	17,798	20,184	22,218	26,618	32,882	38,216
17,645	17,571	17,628	18,498	18,635	20,184	21,255[r]	23,519	24,752	25,233
20,015	20,378	20,701	21,001	21,297	21,569	21,821	22,095	22,446	22,800
7,420	7,694	7,919	8,162	8,396[r]	8,643[r]	8,918[r]	9,321[r]	9,704	10,060
7,152	7,379	7,537	7,780	7,919[r]	8,107[r]	8,363[r]	8,802[r]	9,185	9,363
267	315	382	382	476[r]	536[r]	555[r]	519[r]	519	697
3.6	4.1	4.8	4.7	5.7[r]	6.2[r]	6.2[r]	5.6	5.3	6.9
120.7	122.6	122.7	127.0[r]	127.1	127.8	129.9	135.9	142.8	141.1
31,878	35,303	38,444	43,065	46,706	51,528[r]	57,570[r]	66,358	78,520	90,586
79.3	81.9	87.9	93.7	95.2	100.0	107.0	115.8	118.9	113.6
81.8	83.8	90.0	96.5	95.2	100.0	106.6	115.2	118.5	112.7
73.4	77.7	83.3	83.9	95.8	100.0	106.0	115.4	114.3	106.2
78.9	81.4	87.1	92.3	94.6	100.0	105.0	111.6	115.8	115.7
259.5	264.1	269.9	282.4	286.4	289.9	310.3	376.9	461.3	491.3
83.5	86.5	90.0	94.1	97.2	100.0	104.8	112.7	125.0	138.5

Table 1. Mineral production of Canada, 1974 and 1975 and average 1971-75

	Unit of Measure	1974 Quantity	1974 $000	1975P Quantity	1975P $000	Average 1971-1975 Quantity	Average 1971-1975 $000
Metals							
Antimony	000 lb	. .	5,619	. .	5,516	. .	3,286
Bismuth	000 lb	245	2,006	81	643	189	1,049
Cadmium	000 lb	2,736	10,881	2,682	7,162	3,589	10,400
Calcium	000 lb	1,050	916	826	1,108	670	629
Cobalt	000 lb	3,447	10,114	2,949	11,578	3,483	9,668
Columbium (Cb_2O_5)	000 lb	4,233	6,680	3,714	6,430	3,466	4,702
Copper	000 st	906	1,402,571	798	1,016,819	825	1,028,668
Gold	000 troy oz	1,698	263,794	1,674	276,125	1,933	185,988
Iron ore	000 lt	46,046	724,150	44,121	923,184	43,463	659,520
Iron remelt	000 st	. .	71,286	. .	75,595	. .	53,644
Lead	000 st	324	134,330	373	151,837	370	126,264
Magnesium	000 lb	13,133	9,260	9,922	8,324	12,610	6,553
Molybdenum	000 lb	30,736	61,778	27,414	68,893	27,939	52,991
Nickel	000 st	297	974,594	270	1,109,230	279	882,895
Platinum group	000 troy oz	385	60,794	430	61,231	410	47,700
Selenium	000 lb	600	9,449	670	12,330	618	7,652
Silver	000 troy oz	42,810	198,166	39,101	176,627	44,043	128,269
Tantalum (Ta_2O_5)	000 lb	438	3,576	395	3,260	299	2,230
Tellurium	000 lb	124	1,010	80	763	73	550
Thorium	000 lb	—	—	—	—	—	—
Tin	000 lb	714	2,565	623	2,192	460	1,244
Tungsten (WO_3)	000 lb	3,558	. .	2,987	. .	4,051	. .
Uranium (U_3O_8)	000 lb	9,591	. .	12,251	. .	9,867	. .
Zinc	000 st	1,242	867,135	1,194	895,357	1,258	662,276
Total metals			4,820,674		4,814,204		3,876,178
Nonmetals							
Arsenious oxide	000 lb	—	—	—	—	20	2
Asbestos	000 st	1,812	302,013	1,143	266,943	1,626	242,673
Barite	000 st	86	978	90	1,083	95	996
Feldspar	000 st	—	—	—	—	4	90
Fluorspar	000 st	. .	7,119	. .	7,000	. .	5,398
Gemstones	000 lb	8	19	. .	18	. .	169
Gypsum	000 st	7,964	22,437	6,255	19,720	7,482	19,528
Magnesite, dolomite and brucite	000 st	. .	4,358	. .	4,000	. .	3,323
Nepheline syenite	000 st	617	9,179	520	8,663	556	7,562
Peat moss	000 st	407	20,853	383	20,630	375	16,471
Potash (K_2O)	000 st	6,367	308,925	5,346	346,806	4,895	220,615
Pyrite, pyrrhotite	000 st	54	348	21	90	109	446
Quartz	000 st	2,762	12,184	2,561	13,499	2,661	10,736
Salt	000 st	6,004	60,619	5,683	60,593	5,642	50,220
Soapstone, talc and pyrophyllite	000 st	95	1,913	74	1,683	79	1,579
Sodium sulphate	000 st	703	14,192	546	23,762	556	11,677
Sulphur in smelter gas	000 st	731	9,813	776	10,417	712	8,010
Sulphur, elemental	000 st	5,548	68,556	4,476	89,190	4,281	44,490
Titanium dioxide	000 st	. .	51,931	. .	55,075	. .	46,704
Total nonmetals			895,437		929,172		690,689

Table 1. (concl'd)

	Unit of measure	1974 Quantity	1974 $000	1975[p] Quantity	1975[p] $000	Average 1971-1975 Quantity	Average 1971-1975 $000
Fuels							
Coal	000 st	23,536	302,826	27,000	575,800	22,449	266,137
Natural gas	000 mcf	3,045,506	723,766	3,074,659	1,729,631	2,930,437	728,997
Natural gas byproducts	000 bbl	113,304	653,562	110,468	767,766	106,858	442,865
Petroleum, crude	000 bbl	614,777	3,521,569	525,342	3,781,067	570,138	2,495,020
Total fuels			5,201,723		6,854,264		3,933,019
Structural materials							
Clay products	$000	. .	70,621	. .	69,956	. .	60,900
Cement	000 st	11,436	274,649	10,763	265,283	10,517	235,187
Lime	000 st	2,009	41,812	1,889	40,439	1,852	33,176
Sand and gravel	000 st	263,779	263,985	224,960	260,340	232,137	213,698
Stone	000 st	102,331	177,207	97,100	170,700	89,085	135,293
Total structural materials			828,274		806,718		678,254
Total all minerals			11,746,108		13,404,358		9,178,140

Note:
1. Production statistics for the following are not available for publication: indium, mercury, helium, nitrogen, diatomite, yttrium.
2. Nil production for the following between 1971 and 1975: grindstone, iron oxide, lithia, mica.
3. Only dollar values are available for publication for the following: iron remelt, fluorspar, magnesite, dolomite and brucite, titanium dioxide and clay products.
4. Only quantities are available for publication for tungsten and uranium.

[p]Preliminary; . . Not available or not applicable; — Nil.
lb — pound; st — short ton; troy oz — troy ounce; lt — long ton; mcf — thousand cubic feet; bbl — barrel.

Table 2. Canada, value of mineral production, per capita value of mineral production and population, 1935-75

	Metallics	Industrial minerals	Fuels	Total	Per capita value of mineral production	Population of Canada
			$ million		$	thousand
1935	222	36	55	313	28.84	10,845
1936	260	43	60	363	33.11	10,950
1937	335	57	66	458	41.48	11,045
1938	324	54	65	443	39.71	11,152
1939	343	61	71	475	42.12	11,267
1940	382	69	79	530	46.55	11,381
1941	395	80	85	560	48.69	11,507
1942	392	83	92	567	48.63	11,564
1943	357	80	93	530	44.94	11,795
1944	308	81	97	486	40.67	11,946
1945	317	88	94	499	41.31	12,072
1946	290	110	103	503	40.91	12,292
1947	395	140	110	645	51.38	12,551
1948	488	172	160	820	63.97	12,823
1949	539	178	184	901	67.01	13,447
1950	617	227	201	1,045	76.24	13,712
1951	746	266	233	1,245	88.90	14,009
1952	728	293	264	1,285	88.90	14,459
1953	710	312	314	1,336	90.02	14,845
1954	802	333	353	1,488	97.36	15,287
1955	1,008	373	414	1,795	114.37	15,698
1956	1,146	420	519	2,085	129.65	16,081
1957	1,159	466	565	2,190	131.87	16,610
1958	1,130	460	511	2,101	122.99	17,080
1959	1,371	503	535	2,409	137.79	17,483
1960	1,407	520	566	2,493	139.48	17,870
1961	1,387	542	674	2,603	142.72	18,238
1962	1,496	574	811	2,881	155.05	18,583
1963	1,510	632	885	3,027	159.91	18,931
1964	1,702	690	973	3,365	174.45	19,290
1965	1,908	761	1,046	3,715	189.11	19,644
1966	1,985	844	1,152	3,981	198.88	20,015
1967	2,285	861	1,235	4,381	214.99	20,378
1968	2,493	886	1,343	4,722	228.10	20,701
1969	2,378	891	1,465	4,734	225.42^r	21,001
1970	3,073	931	1,718	5,722	268.68	21,297
1971	2,940	1,008	2,015	5,963	276.46	21,569
1972	2,956^r	1,085	2,367^r	6,408^r	293.66^r	21,821
1973	3,850	1,292^r	3,227	8,369^r	378.77	22,095
1974	4,820	1,724	5,202	11,746	523.30	22,446
1975^p	4,814	1,736	6,854	13,404	587.91	22,800

^{r} Revised; ^{p} Preliminary.

Table 3. Canada, value of mineral production by provinces, territories and mineral classes, 1975^p

	Metals		Industrial minerals		Fuels		Total	
	$000	% of total	$000	% of total	$000	% of total	$000	% of total
Alberta	—	—	172,917	9.96	5,827,932	85.03	6,000,849	44.77
Ontario	1,965,449	40.80	364,151	20.98	11,604	0.17	2,341,204	17.46
British Columbia	588,692	12.23	128,824	7.42	506,399	7.39	1,223,915	9.13
Quebec	656,624	13.64	485,825	27.99	8	. .	1,142,457	8.52
Saskatchewan	18,542	0.39	394,015	22.70	413,979	6.04	826,536	6.17
Newfoundland	526,875	10.95	41,337	2.38	—	—	568,212	4.24
Manitoba	457,664	9.51	43,868	2.52	31,657	0.46	533,189	3.98
New Brunswick	221,882	4.61	22,355	1.29	7,156	0.11	251,393	1.88
Yukon	196,689	4.09	31,970	1.84	239	. .	228,898	1.71
Northwest Territories	181,787	3.78	—	—	7,690	0.11	189,477	1.41
Nova Scotia	—	—	49,088	2.83	47,600	0.69	96,688	0.72
Prince Edward Island	—	—	1,540	0.09	—	—	1,540	0.01
Total Canada	4,814,204	100.0	1,735,890	100.0	6,854,264	100.00	13,404,358	100.00

^{p}Preliminary; — Nil; . . Not available or not applicable.

Table 4. Canada, production of leading minerals

	Unit of measure	Nfld.	P.E.I.	N.S.	N.B.	Quebec	Ontario
Petroleum, crude	000 bbl	—	—	—	8	—	721
	$000	—	—	—	11	—	5,191
Natural gas	000 mcf	—	—	—	90	50	12,671
	$000	—	—	—	45	8	6,413
Nickel	st	—	—	—	—	—	199,440
	$000	—	—	—	—	—	815,934
Copper	st	8,190	—	—	13,139	129,858	292,296
	$000	10,434	—	—	16,739	165,440	372,385
Iron ore	000 st	25,576	—	—	—	12,200	10,264
	$000	486,636	—	—	—	207,942	214,007
Zinc	st	27,725	—	—	203,143	131,015	371,338
	$000	20,794	—	—	152,357	98,261	278,504
Coal	000 st	—	—	1,850	450	—	—
	$000	—	—	47,600	7,100	—	—
Potash (K_2O)	000 st	—	—	—	—	—	—
	$000	—	—	—	—	—	—
Gold	000 troy oz	13	—	—	5	465	775
	$000	2,066	—	—	757	76,771	127,833
Asbestos	000 st	64	—	—	—	854	16
	$000	18,135	—	—	—	176,634	1,395
Cement	000 st	. .	—	. .	. .	3,489	4,021
	$000	3,468	—	3,348	4,403	90,715	92,491
Sand and gravel	000 st	5,900	960	8,900	6,500	43,000	76,200
	$000	7,800	1,540	12,500	4,500	31,500	92,000
Silver	000 troy oz	528	—	—	4,790	3,245	14,506
	$000	2,384	—	—	21,638	14,656	65,525
Stone	000 st	600	—	1,300	2,600	53,100	33,700
	$000	1,900	—	4,300	5,200	84,200	62,000
Lead	st	11,176	—	—	62,264	1,597	7,427
	$000	4,549	—	—	25,341	650	3,023
Sulphur, elemental	000 st	—	—	—	—	—	1
	$000	—	—	—	—	—	29
Iron remelt	st	—	—	—	—	. .	—
	$000	—	—	—	—	75,595	—
Clay products	$000	300	—	3,155	1,310	12,507	38,363
Molybdenum	000 lb	—	—	—	—	627	—
	$000	—	—	—	—	1,590	—
Platinum group	000 troy oz	—	—	—	—	—	430
	$000	—	—	—	—	—	61,231
Salt	000 st	—	—	795	—	—	4,253
	$000	—	—	12,355	—	—	37,018
Titanium dioxide	st	—	—	—	—	. .	—
	$000	—	—	—	—	55,075	—
Lime	000 st	—	—	—	. .	641	958
	$000	—	—	—	1,275	15,715	18,193
Gypsum	000 st	508	—	4,406	59	—	742
	$000	1,964	—	12,490	230	—	2,620
Total leading minerals	$000	560,430	1,540	95,748	240,906	1,107,259	2,294,155
Total all minerals	$000	568,212	1,540	96,688	251,393	1,142,457	2,341,204
Leading minerals as % of all minerals		98.6	100.0	99.0	95.8	96.9	98.0

[p]Preliminary; — Nil; . . Not available or not applicable.

by provinces and territories, 1975p

	Manitoba	Sask.	Alberta	B.C.	Yukon	N.W.T.	Total Canada
	4,441	58,171	446,359	14,432	—	1,210	525,342
	31,657	389,746	3,254,971	95,251	—	4,240	3,781,067
	—	61,000	2,580,006	389,570	2,076	29,196	3,074,659
	—	9,455	1,639,898	70,123	239	3,450	1,729,631
	70,386	—	—	—	—	—	269,826
	293,296	—	—	—	—	—	1,109,230
	70,782	8,502	—	265,999	9,090	276	798,132
	90,176	10,831	—	338,883	11,580	351	1,016,819
	—	—	—	1,375	—	—	49,415
	—	—	—	14,599	—	—	923,184
	73,073	4,568	—	109,372	126,879	146,696	1,193,809
	54,805	3,426	—	82,029	95,159	110,022	895,357
	—	3,750	10,500	10,450	—	—	27,000
	—	8,900	185,000	327,200	—	—	575,800
	—	5,346	—	—	—	—	5,346
	—	346,806	—	—	—	—	346,806
	46	14	—	144	26	186	1,674
	7,528	2,352	—	23,821	4,245	30,752	276,125
	—	—	—	97	112	—	1,143
	—	—	—	38,809	31,970	—	266,943
	523	240	977	1,026	—	—	10,763
	10,468	6,249	25,410	28,731	—	—	265,283
	18,400	11,500	23,400	30,200	—	—	224,960
	24,800	9,800	40,300	35,600	—	—	260,340
	994	272	—	6,076	6,516	2,174	39,101
	4,492	1,230	—	27,447	29,434	9,821	176,627
	1,700	—	200	3,900	—	—	97,100
	2,600	—	1,000	9,500	—	—	170,700
	144	—	—	76,447	138,233	75,777	373,065
	59	—	—	31,114	56,260	30,841	151,837
	1	15	4,404	55	—	—	4,476
	13	232	87,749	1,167	—	—	89,190
	—	—	—	—	—	—	. .
	—	—	—	—	—	—	75,595
	676	2,672	7,299	3,674	—	—	69,956
	—	—	—	26,787	—	—	27,414
	—	—	—	67,303	—	—	68,893
	—	—	—	—	—	—	430
	—	—	—	—	—	—	61,231
	30	292	313	—	—	—	5,683
	170	6,891	4,159	—	—	—	60,593
	—	—	—	—	—	—	. .
	—	—	—	—	—	—	55,075
	. .	—	133	40	—	—	1,889
	1,584	—	2,659	1,013	—	—	40,439
	90	—	—	450	—	—	6,255
	202	—	—	2,214	—	—	19,720
	522,526	798,590	5,248,445	1,198,478	228,887	189,477	12,486,441
	533,189	826,536	6,000,849	1,223,915	228,898	189,477	13,404,358
	98.0	96.6	87.5	97.9	99.9	100.0	93.2

Table 5. Canada, percentage contribution of leading minerals to total value of mineral production, 1966-75

	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975[p]
Petroleum, crude	19.8	19.8	19.8[r]	21.4	20.2	22.7	24.5	26.8[r]	30.0	28.2
Natural gas	4.5[r]	4.5	4.8	5.5	5.5	5.7	6.2	5.4	6.2	12.9
Nickel	9.5	10.6	11.2[r]	10.2	14.5	13.4	11.2	9.7	8.3	8.3
Copper	11.4	13.3	12.9[r]	12.4	13.6	12.7	12.5[r]	13.8	11.9	7.6
Iron ore	10.8	10.7	11.3[r]	9.6	10.3	9.3	7.6	7.2	6.2	6.9
Zinc	7.3	7.3	6.9	7.8	7.0	7.0	7.5[r]	7.8	7.4	6.7
Coal	2.0[r]	1.3	1.1	1.1	1.5	2.0	2.4	2.1	2.6	4.3
Potash (K_2O)	1.6	1.5	1.4[r]	1.5	1.9	2.3	2.1	2.1	2.6	2.6
Gold	3.1	2.5	2.2[r]	2.0	1.5	1.3	1.9	2.3	2.2	2.0
Asbestos	4.1	3.7	3.9[r]	4.1	3.6	3.4	3.2	2.8	2.6	2.0
Cement	3.9	3.3	3.1	3.4	2.7	3.2	3.3	2.9	2.3	2.0
Sand and gravel	3.8	3.3	2.7	2.6	2.3	2.6	2.8	2.5	2.3	1.9
Silver	1.2	1.4	2.2	1.8	1.4	1.2	1.2	1.4	1.7	1.3
Stone	2.8[r]	2.3	2.0	1.9	1.5	1.6	1.6	1.5	1.5	1.3
Lead	2.3	2.0	1.9	2.0	2.2	1.8	1.8	1.5	1.1	1.1
Sulphur, elemental	1.0	1.6	1.7	1.3	0.5	0.4	0.3	0.3	0.6	0.7
Iron remelt	0.4	0.4	0.5	0.6	0.6	0.5	0.7	0.6	0.6	0.6
Clay products	1.1	1.0	1.0	1.1	0.9[r]	0.8	0.8	0.7	0.6	0.5
Molybdenum	0.9	0.9	0.8	1.1	1.0	0.6	0.7	0.6	0.5	0.5
Platinum group	0.8	0.8	1.0[r]	0.7	0.8	0.7	0.5	0.5	0.5	0.5
Salt	0.6	0.6	0.7	0.6	0.6	0.7	0.6	0.6	0.5	0.5
Titanium dioxide	0.5[r]	0.5	0.6	0.6	0.6	0.7	0.6	0.6	0.4	0.4
Lime	0.5	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.3
Gypsum	0.3	0.3	0.3	0.3	0.2	0.3	0.3	0.3	0.2	0.1
Other minerals	5.8	6.0	5.6[r]	6.0	4.7[r]	4.7	5.3	5.6[r]	6.8	6.8
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

[p] Preliminary; [r] Revised.

Table 6. Canada, value of mineral production by provinces and territories, 1966-75

	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975^p
					($ million)					
Alberta	849	974	1,092	1,205	1,396	1,641	1,979	2,760^r	4,519	6,001
Ontario	958	1,195	1,356	1,223	1,593	1,555	1,536^r	1,855^r	2,430	2,341
British Columbia	331	380	389	434	490	541	678	978^r	1,156	1,224
Quebec	771	741	725	717	803	766	786	936^r	1,226	1,143
Saskatchewan	349	362	357	345	379	410	410	510	790	827
Newfoundland	244	266	310	257	353	343	291	374^r	449	568
Manitoba	179	185	210	246	332	330	323	414^r	486	533
New Brunswick	90	90	88	95	134	107	120	164^r	214	251
Yukon	12	15	21	35	77	93	107	151	172	229
Northwest Territories	111	118	116	119	105	116	120	165	223	189
Nova Scotia	86	53	57	59	59	60	57^r	61^r	80	97
Prince Edward Island	1	2	1	1	1	1	1	2	1	2
Total	3,981	4,381	4,722	4,736	5,722	5,963	6,408^r	8,370^r	11,746	13,404

^{p}Preliminary; ^{r}Revised.

Table 7. Canada, percentage contribution of provinces and territories to total value of mineral production, 1966-75

	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975^p
Alberta	21.3	22.2	23.1	25.4	24.4	27.5	30.9	33.0	38.5	44.8
Ontario	24.1	27.3	28.7	25.8	27.8	26.0	23.9	22.2	20.7	17.5
British Columbia	8.3	8.7	8.2	9.2	8.6	9.1	10.6	11.7	9.9	9.1
Quebec	19.4	16.9	15.4	15.2	14.0	12.9	12.3	11.2^r	10.4	8.5
Saskatchewan	8.7	8.3	7.6	7.3	6.6	6.9	6.4	6.1	6.7	6.2
Newfoundland	6.1	6.1	6.6	5.4	6.2	5.8	4.5	4.5	3.8	4.2
Manitoba	4.5	4.2	4.4	5.2	5.8	5.5	5.0	4.9^r	4.1	4.0
New Brunswick	2.3	2.1	1.9	2.0	1.8	1.8	1.9	1.9	1.8	1.9
Yukon	0.3	0.3	0.5	0.7	1.4	1.6	1.7	1.8	1.5	1.7
Northwest Territories	2.8	2.7	2.4	2.5	2.4	1.9	1.9	2.0	1.9	1.4
Nova Scotia	2.2	1.2	1.2	1.3	1.0	1.0	0.9	0.7	0.7	0.7
Prince Edward Island	0.02	0.04	0.02	0.02	0.02	0.02	0.02	0.02	0.01	0.02
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

^{p}Preliminary; ^{r}Revised.

Table 8. Canada's world role as a producer of certain

		World production
Nickel (mine production)	1974[p] st % of world total	822,392
Zinc (mine production)	1974 st % of world total	6,382,957
Asbestos	1974[p] st % of world total	4,513,173
Silver	1974[p] 000 troy oz % of world total	296,293
Potash (K_2O equivalent)	1974[p] 000 st % of world total	26,363
Titanium concentrate (ilmenite)	1974[p] st % of world total	4,084,812
Uranium (U_3O_8 concentrates)	1974[p] st % of world total	24,270
Molybdenum	1974[p] st % of world total	94,704
Gypsum	1974[p] 000 st % of world total	66,380
Elemental sulphur	1974[p] 000 st % of world total	35,947
Platinum group metals (mine production)	1974[p] troy oz % of world total	5,784,440
Gold (mine production)	1974[p] troy oz % of world total	39,760,673
Copper (mine production)	1974 st % of world total	8,627,855
Lead (mine production)	1974 st % of world total	3,875,652
Aluminum (primary metal)	1974 st % of world total	15,299,098
Cadmium (smelter production)	1974[p] 000 lb % of world total	37,316
Iron ore	1974 000 lt % of world total	838,700

[p] Preliminary; [e] Estimated.

important minerals, 1974

Rank of six leading countries					
1	2	3	4	5	6
Canada 296,600 36.1	New Caledonia 142,800 17.4	U.S.S.R. 135,000[e] 16.4	Australia 44,500 5.4	Cuba 35,000[e] 4.3	Dominican Republic 33,000 4.0
Canada 1,242,314 19.5	U.S.S.R. 1,047,000[e] 16.4	U.S.A. 499,872 7.8	Australia 468,576 7.3	Peru 426,600 6.7	Mexico 289,592 4.5
Canada 1,811,938 40.1	U.S.S.R. 1,488,120[e] 33.0	Republic of South Africa 369,739 8.2	People's Rep. of China 231,485[e] 5.1	Italy 165,629 3.7	U.S.A. 112,533 2.5
Canada 42,810 14.4	U.S.S.R. 42,000[e] 14.2	Peru 41,000 13.8	Mexico 37,546 12.7	U.S.A. 33,762 11.4	Australia 21,615 7.3
U.S.S.R. 6,700[e] 25.4	**Canada** 6,367 24.2	East Germany 3,158 12.0	West Germany 2,888 11.0	U.S.A. 2,552 9.7	France 2,508 9.5
Norway 934,875 22.9	**Canada** 931,170 22.8	Australia 909,395 22.3	U.S.A. 744,572 18.2	Malaysia 210,000[e] 5.1	Finland 168,000[e] 4.1
U.S.A. 11,528 47.5	**Canada** 4,795 19.8	Republic of South Africa 3,389 14.0	France 2,200 9.1	Niger 1,232 5.1	Gabon 852 3.5
U.S.A. 56,006 59.1	**Canada** 15,368 16.2	Chile 10,755 11.4	U.S.S.R. 9,700[e] 10.2	People's Rep. of China 1,650[e] 1.7	Peru 825[e] 0.9
U.S.A. 11,999 18.1	**Canada** 7,964 12.0	France 6,856 10.3	U.S.S.R. 5,181[e] 7.8	Spain 4,850[e] 7.3	Italy 3,858[e] 5.8
U.S.A. 11,797 32.8	**Canada** 5,548 15.4	Poland 4,442 12.4	Japan 3,095 8.6	U.S.S.R. 2,756 7.7	Mexico 2,561 7.1
Republic of South Africa 2,834,500[e] 49.0	U.S.S.R. 2,500,000[e] 43.2	**Canada** 384,618 6.6	Colombia 27,000[e] 0.5	Japan 18,870 0.3	U.S.A. 12,657 0.2
Republic of South Africa 24,362,868 61.3	U.S.S.R. 7,300,000[e] 18.4	**Canada** 1,698,392 4.3	U.S.A. 1,126,886 2.8	Ghana 760,000[e] 1.9	Papua-New Guinea 726,047 1.8
U.S.A. 1,597,002 18.5	U.S.S.R. 1,300,000[e] 15.1	Chile 994,400 11.5	**Canada** 905,417 10.5	Zambia 769,400 8.9	Zaire 551,200 6.4
U.S.A. 663,870 17.1	U.S.S.R. 650,000[e] 16.8	Australia 393,150 10.1	**Canada** 324,375 8.4	Mexico 240,325 6.2	Peru 212,744 5.5
U.S.A. 4,903,000 32.0	U.S.S.R. 2,425,100[e] 15.9	Japan 1,239,000 8.1	**Canada** 1,125,329 7.4	West Germany 759,349 5.0	Norway 730,607 4.8
Japan 6,672 17.9	U.S.A. 6,666 17.9	U.S.S.R. 5,840[e] 15.7	West Germany 3,280[e] 8.8	**Canada** 2,736 7.3	Belgium 2,300[e] 6.2
U.S.S.R. 219,676[e] 26.2	Australia 93,500 11.1	U.S.A. 84,676 10.1	France 53,580 6.4	**Canada** 46,046 5.5	People's Rep. of China 45,274 5.4

Table 9. Canada, census value-added, commodity-producing industries, 1967-73

	1967	1968	1969	1970	1971	1972	1973[p]
				($ million)			
Primary industries							
Agriculture	2,693	2,870	3,032	2,775	3,035	3,442	5,078
Forestry	615	644	734	683	686	814	1,216
Fishing	164	186	184	204	205	237	321
Trapping	10	12	16	13	11	17	29
Mining[1]	2,918	3,176	3,342	3,805	3,810	4,267	5,533
Electrical power	1,234	1,360	1,511	1,707	1,855[r]	2,051	2,345
Total	7,634	8,248	8,819	9,187	9,602[r]	10,828	14,522
Secondary industries							
Manufacturing	17,006	18,332	20,134	20,048	21,738[r]	24,292	28,236
Construction	5,148	5,269	5,794	6,167	7,581	8,244	9,609
Total	22,154	23,601	25,928	26,215	29,319[r]	32,536	37,845
Grand total	29,788	31,849	34,747	35,402	38,921	43,364	52,367

[1]Excludes cement, lime and clay and clay products (from domestic clays) manufacture. These industries are included under Manufacturing.
[p]Preliminary; [r]Revised.

Table 10. Canada, census value-added, mining and mineral manufacturing industries, 1969-73

	1969	1970	1971	1972	1973p
			($ thousand)		
Mining					
Metallic minerals					
Placer gold	155	120	92	110	. .
Gold quartz	74,993	63,902	59,516	74,938	119,165
Copper-gold-silver	465,309	432,678	378,384	446,121	1,023,575
Silver-cobalt	6,088	4,184	2,874	3,587	. . [1]
Silver-lead-zinc	171,239	171,603	156,050	175,301	291,706
Nickel-copper	386,383	634,644	448,779	521,009	813,843
Iron	315,378	367,599	345,900	281,757	353,790
Miscellaneous metal mines	104,433	101,824	90,705	95,392	105,588
Total	1,523,978	1,776,554	1,482,300	1,598,215	2,707,667
Industrial minerals					
Asbestos	157,855	168,612	165,018	160,859	174,406
Feldspar, quartz and nepheline syenite	9,065	8,939	9,473	11,086	13,981
Gypsum	11,496	10,756	11,608	14,609	16,796
Peat	8,066	9,432	11,227	10,706	13,523
Potash	. . [2]	85,743	107,396	111,970	129,249
Salt	22,238	28,124	29,842	31,879	36,388
Sand and gravel	44,329	42,059	51,454	51,400	55,500
Stone	45,153	47,165	50,827	57,442	65,668
Talc and soapstone	785	784	897	1,174	1,464
Miscellaneous nonmetals	62,005	12,107	10,101	11,830	12,703
Total	360,992	413,721	447,843	462,955	519,678
Fuels					
Coal	64,321	74,035	103,918	130,144	164,858
Petroleum and natural gas	1,392,994	1,540,581	1,775,798	2,075,454	2,871,455
Total	1,457,315	1,614,616	1,879,716	2,205,598	3,036,313
Total mining industry	3,342,285	3,804,891	3,809,859	4,266,768	6,263,658
Mineral manufacturing					
Primary metal industries					
Iron and steel mills	708,727	835,956	866,948	909,369	1,154,569
Steel pipe and tube mills	75,525	76,558	86,564	113,801	117,375
Iron foundries	123,331	119,721	120,039	135,431	161,217
Smelting and refining	513,806	552,540	545,192	530,569	551,062
Aluminum rolling, casting and extruding	82,837	80,163	87,491	98,265	95,377
Copper and alloy rolling, casting and extruding	61,054	52,319	55,780	67,253	91,219
Metal rolling, casting and extruding, nes	55,867	51,831	50,144	62,630	80,093
Total	1,621,147	1,769,088	1,812,158	1,917,318	2,250,912
Nonmetallic mineral products industries					
Cement manufacturers	117,521	115,175	131,404	155,968	171,517
Lime manufacturers	10,368	11,248	11,937	12,605	17,858
Gypsum products manufacturers	36,877	31,874	40,395	. . [3]	. . [3]
Concrete products manufacturers	126,965	125,170	160,480	175,927	191,630

Table 10. (concl'd)

	1969	1970	1971	1972	1973p
			($ thousand)		
Ready-mix concrete manufacturers	109,951	108,467	133,290	156,206	195,321
Clay products (domestic clay)	37,270	32,553	37,514	39,572	41,239
Clay products (imported clay)	22,399	21,947	22,791	26,546	33,410
Refractories manufacturers	19,759	23,212	20,741	19,375	24,652
Stone products manufacturers	6,630	5,960	10,622	9,330	10,898
Mineral wool manufacturers	24,748	24,692	29,535	. . [3]	. . [3]
Asbestos products manufacturers	31,135	31,600	37,269	. . [3]	. . [3]
Glass manufacturers	100,230	104,955	123,390	143,531	158,024
Glass products manufacturers	50,784	44,434	55,878	58,248	72,716
Abrasive manufacturers	33,228	31,037	27,944	32,713	37,373
Other nonmetallic mineral products industries	11,074	11,415	12,497	143,197	154,738
Total	738,939	723,739	855,687	973,218	1,109,376
Petroleum and coal products industries					
Petroleum refining	293,416	331,965	401,032	431,301	537,380
Manufacturers of lubricating oil and greases	15,486	15,908	17,495	19,529	21,181
Other petroleum and coal products industries	8,266	8,355	10,629	11,735	15,367
Total	317,168	356,228	429,156	462,565	573,928
Total mineral manufacturing	2,677,254	2,849,055	3,097,001	3,353,101	3,934,216
Total mining and mineral manufacturing	6,019,539	6,653,946	6,906,860	7,619,869	10,197,874

[1]Included with silver-lead-zinc mines. [2]Included with miscellaneous nonmetals. [3]Included with other nonmetallic mineral products industries.
pPreliminary; . . Not available or not applicable; nes Not elsewhere specified.

Table 11. Canada, indexes of physical volume of total industrial production, mining and mineral manufacturing, 1961-75
(1971=100)

	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975^p
Total industrial production	54.3	58.8	62.5	68.7	74.4	79.3	81.9	87.9	93.7	95.2	100.0	107.0	115.8	118.9	113.6
Total mining	54.7	58.1	61.3	68.9	72.1	73.4	77.7	83.3	83.9	95.8	100.0	106.0	115.4	114.3	106.2
Metals															
All metals	65.2	66.7	67.9	78.4	80.1	79.0	84.3	88.5	83.1	99.2	100.0	96.5	106.2	105.7	99.7
Placer gold and gold quartz mines	180.2	171.4	164.7	162.3	157.5	148.1	132.6	120.4	116.9	104.0	100.0	90.9	81.1	69.9	71.2
Iron mines	29.5	41.1	50.3	61.6	66.4	71.3	77.0	92.6	81.1	102.5	100.0	82.4	106.7	106.9	106.2
Miscellaneous metal mines, nes	71.2	69.4	68.1	79.3	80.2	77.3	83.9	84.8	81.6	97.7	100.0	100.3	107.3	107.2	99.5
Fuels															
All fuels	40.2	45.9	49.4	53.4	57.0	61.2	66.7	72.7	79.9	92.2	100.0	119.1	129.8	123.7	114.5
Coal	67.1	65.7	70.1	73.7	75.1	69.6	69.2	67.2	66.8	86.0	100.0	148.3	160.6	158.4	201.7
Crude petroleum and natural gas	37.4	43.9	47.3	51.4	55.2	60.4	66.5	73.3	81.2	92.8	100.0	116.7	127.2	120.9	107.3
Nonmetals															
All nonmetals	45.5	49.5	55.3	63.4	69.0	74.8	79.1	87.4	92.1	96.1	100.0	98.4	107.6	120.2	100.3
Asbestos	68.4	70.5	74.5	83.3	80.8	87.3	85.9	92.9	90.9	100.1	100.0	96.7	102.6	101.0	64.7
Mineral manufacturing															
Primary metals	57.9	61.1	66.2	74.4	81.3	84.6	81.8	91.7	95.5	99.1	100.0	104.8	113.2	119.0	107.9
Nonmetallic mineral product	63.5	73.1	74.1	81.3	88.5	92.1	86.0	93.5	98.0	92.7	100.0	106.7	118.3	123.3	118.7
Petroleum and coal products	60.5	65.8	70.9	71.7	75.3	78.1	79.0	87.3	90.9	92.7	100.0	110.5	121.3	127.0	124.5

^{p}Preliminary; nes Not elsewhere specified.

Table 12. Canada, indexes of real domestic product by industries, 1965-75 (1971=100)

	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975[p]
Real domestic product, all industries	73.7	78.9	81.4	87.1	92.3	94.6	100.0	105.0	111.6	115.8	115.7
Agriculture	83.6	95.5	77.7	82.5	87.3	86.1	100.0	90.1	87.4	82.9	81.6
Forestry	90.7	98.3	96.5	97.2	103.3	101.3	100.0	99.2	121.6	121.1	98.4
Fishing and trapping	98.8	109.5	103.9	117.8	104.5	107.0	100.0	96.9	103.5	84.8	74.4
Mining (including milling), quarries and oil wells	72.1	73.4	77.7	83.3	83.9	95.8	100.0	106.0	115.4	114.3	106.2
Electric power, gas and water utilities	62.6	68.1	72.8	78.4	85.6	93.6	100.0	110.9	121.3	129.2	130.4
Manufacturing	76.4	81.8	83.8	90.0	96.5	95.2	100.0	106.6	115.2	118.5	112.7
Construction	79.5	85.6	85.3	89.0	91.8	90.9	100.0	102.7	108.0	107.1	104.6
Transportation, storage and communication	69.8	75.5	79.5	84.7	90.6	95.2	100.0	107.3	115.9	123.4	124.7
Trade	75.9	80.7	84.8	88.3	92.8	93.8	100.0	107.0	112.4	118.1	118.0
Community, business and personal service	68.9	75.1	80.4	85.8	92.0	95.9	100.0	104.2	108.9	114.6	119.1
Finance, insurance and real estate	67.4	70.1	73.3	85.2	90.4	94.8	100.0	104.2	111.0	117.6	122.2
Public administration and defence	81.8	84.7	89.3	90.7	92.7	95.9	100.0	104.5	109.5	113.9	118.6

[p] Preliminary.

Table 13. Canada, value of exports of crude minerals and fabricated mineral products, by main groups, 1971-75

	1971	1972	1973	1974	1975[p]
			($ million)		
Ferrous					
Crude material	431.8	371.8	497.7	573.9	717.9
Fabricated material	463.6	485.9	598.7	913.1	909.6
Total	895.4	857.7	1,096.4	1,487.0	1,627.5
Nonferrous					
Crude material	954.8	1,014.1	1,501.8	1,799.3	1,513.2
Fabricated material[1]	1,389.7	1,388.9	1,897.8	2,089.3	1,831.9
Total	2,344.5	2,403.0	3,399.6	3,888.6	3,345.1
Nonmetals					
Crude material	456.9	475.5	595.5	792.5	792.1
Fabricated material	100.6	133.2	166.2	174.8	160.7
Total	557.5	608.7	761.7	967.3	952.8
Mineral fuels					
Crude material	1,124.6	1,420.9	1,998.4	4,219.6	4,637.2
Fabricated material	117.0	209.5	311.6	615.1	638.5
Total	1,241.6	1,630.4	2,310.0	4,834.7	5,275.7
Total minerals and products					
Crude material	2,968.1	3,282.3	4,593.4	7,385.3	7,660.4
Fabricated material	2,070.9	2,217.5	2,974.3	3,792.3	3,540.7
Total	5,039.0	5,499.8	7,567.7	11,177.6	11,201.1

[1] Includes gold, refined and unrefined.
[p] Preliminary.

Table 14. Canada, value of imports of crude minerals and fabricated mineral products, by main groups, 1971-75

	1971	1972	1973	1974	1975p
			($ million)		
Ferrous					
Crude material	50.9	53.1	75.3	94.6	179.5
Fabricated material	805.0	850.4	1,022.1	1,759.8	1,494.6
Total	855.9	903.5	1,097.4	1,854.4	1,674.1
Nonferrous[1]					
Crude material	192.0	185.8	255.1	302.7	288.9
Fabricated material	301.4	343.7	474.0	816.2	622.1
Total	493.4	529.5	729.1	1,118.9	911.0
Nonmetals					
Crude material	73.1	71.6	89.0	120.7	183.0
Fabricated material	180.3	198.7	243.1	326.1	359.0
Total	253.4	270.3	332.1	446.8	542.0
Mineral fuels					
Crude material	700.0	867.6	1,116.1	2,955.5	3,888.4
Fabricated material	213.4	209.2	214.5	373.6	275.8
Total	913.4	1,076.8	1,330.6	3,329.1	4,164.2
Total minerals and products					
Crude material	1,016.0	1,178.1	1,535.5	3,473.5	4,539.8
Fabricated material	1,500.1	1,602.0	1,953.7	3,275.7	2,751.5
Total	2,516.1	2,780.1	3,489.2	6,749.2	7,291.3

[1] Includes gold, refined and unrefined.
p Preliminary.

Table 15. Canada, value of exports of crude minerals and fabricated mineral products in relation to total export trade, 1971-75

	1971		1972		1973		1974		1975[p]	
	$ million	% of total	$ million	% of total	$ million	% of total	$ million	% of total	$ million	% of total
Crude material	2,968.1	17.1	3,282.3	16.7	4,593.4	18.5	7,385.3	23.5	7,660.4	23.7
Fabricated material	2,070.9	11.9	2,217.5	11.3	2,974.3	12.0	3,792.3	12.1	3,540.7	11.0
Total	5,039.0	29.0	5,499.8	28.0	7,567.7	30.5	11,177.6	35.6	11,201.1	34.7
Total exports,[1] all products	17,396.6	100.0	19,670.8[r]	100.0	24,836.9	100.0	31,411.9	100.0	32,325.0	100.0

[1] Includes gold, refined and unrefined.
[p] Preliminary; [r] Revised.

Table 16. Canada, value of imports of crude minerals and fabricated mineral products in relation to total import trade, 1971-75

	1971		1972		1973		1974		1975[p]	
	$ million	% of total	$ million	% of total	$ million	% of total	$ million	% of total	$ million	% of total
Crude material	1,016.0	6.5	1,178.1	6.3	1,535.5	6.6	3,473.5	11.0	4,539.8	13.1
Fabricated material	1,500.1	9.6	1,602.0	8.6	1,953.7	8.4	3,275.7	10.3	2,751.5	7.9
Total	2,516.1	16.1	2,780.1	14.9	3,489.2	15.0	6,749.2	21.3	7,291.3	21.0
Total imports,[1] all products	15,618.1	100.0	18,669.4	100.0	23,323.5	100.0	31,639.4	100.0	34.635.5	100.0

[1] Includes gold, refined and unrefined.
[p] Preliminary.

Table 17. Canada, value of exports of crude minerals and fabricated mineral products, by main groups and destination, 1975^p

	Britain	United States	Other countries	Total
	($ million)			
Ferrous materials and products	68.1	1,098.8	460.5	1,627.4
Nonferrous materials and products[1]	595.1	1,329.2	1,420.9	3,345.2
Nonmetallic mineral materials and products	35.2	534.6	383.0	952.8
Mineral fuels, materials and products	21.8	4,656.4	597.5	5,275.7
Total	720.2	7,619.0	2,861.9	11,201.1
Percentage of total mineral exports	6.4	68.0	25.6	100.0

[1] Includes gold, refined and unrefined.
^p Preliminary.

Table 18. Canada, value of imports of crude minerals and fabricated mineral products, by main groups and origin, 1975^p

	Britain	United States	Other countries	Total
	($ million)			
Ferrous materials and products	112.9	1,006.9	554.4	1,674.2
Nonferrous materials and products[1]	26.0	517.6	367.4	911.0
Nonmetallic mineral materials and products	19.2	394.7	128.0	541.9
Mineral fuels, materials and products	6.9	738.9	3,418.4	4,164.2
Total	165.0	2,658.1	4,468.2	7,291.3
Percentage of total mineral imports	2.2	36.5	61.3	100.0

[1] Includes gold, refined and unrefined.
^p Preliminary.

Table 19. Canada, value of exports of crude minerals and fabricated mineral products, by commodity and destination, 1975^p

	U.S.A.	Britain	E.F.T.A.[1]	E.E.C.[2]	Japan	Other countries	Total
				($ thousand)			
Aluminum	287,127	12,308	2,818	21,717	29,718	110,502	464,190
Asbestos	108,916	23,943	5,897	77,834	13,858	87,564	318,012
Copper	184,785	121,651	42,868	177,765	227,458	50,533	805,060
Fuels	4,656,459	21,778	15,042	60,126	478,735	43,573	5,275,713
Iron Ore	429,157	45,023	2,945	144,054	47,366	17,183	685,728
Lead	10,078	609	—	7,688	32,348	5,323	56,046
Molybdenum	4,019	9,806	1,633	37,143	19,115	1,560	73,276
Nickel	377,576	296,009	124,496	66,613	36,226	28,844	929,764
Primary ferrous metals	79,088	10,338	485	31,831	32	19,497	141,271
Uranium	28,129	17,937	—	—	986	—	47,052
Zinc	176,444	46,084	1,081	173,123	75,292	30,473	502,497
All other minerals[3]	1,277,306	114,668	13,744	99,254	60,465	337,112	1,902,549
Total	7,619,084	720,154	211,009	897,148	1,021,599	732,164	11,201,158

[1]European Free Trade Association; includes Austria, Norway, Portugal, Sweden, Switzerland, Finland, and Iceland.
[2]European Economic Community; includes Belgium-Luxembourg, France, Italy, Netherlands, West Germany, Denmark, and Ireland.
[3]Includes gold, refined and unrefined.
^p Preliminary; — Nil.

Table 20. Canada, reported consumption of minerals

	Unit of Measure	1972 Consumption	1972 Production	1972 Consumption as % of Production	1973 Consumption	1973 Production	1973 Consumption as % of Production
Metals							
Aluminum	st	333,550	999,940	33.4	365,728[r]	1,025,381[r]	35.7[r]
Antimony	lb	2,026,300	. .	. .	979,566	. .	. .
Bismuth	lb	37,892	275,029	13.8	56,852	70,684	80.4
Cadmium	lb	123,395	4,267,987	2.9	120,958	4,196,594	2.9
Chromium (chromite)	st	62,712	—	. .	38,030	—	. .
Cobalt	lb	381,260	3,351,108	11.4	431,420	3,344,352	12.9
Copper	st	228,907[1]	793,303	28.9	254,613[1]	908,241	28.0
Lead	st	116,234[2]	369,425	31.5	119,082[2]	376,939	31.6
Magnesium	st	5,922[r]	5,924	100.0	7,293[r]	6,840	106.6
Manganese ore	st	183,175	—	. .	188,072	—	. .
Mercury	lb	114,636	1,112,412	10.3	72,663	950,000	7.6
Molybdenum (Mo content)	lb	2,708,059	28,493,007	9.5	4,434,714	30,391,463	14.6
Nickel	st	10,187	258,987	3.9	11,862	274,527	4.3
Selenium	lb	20,677	582,060	3.6	22,435	521,110	4.3
Silver	troy oz	8,424,314	44,792,209	18.8	16,870,929	47,487,589	35.5
Tellurium	lb	1,419	45,649	3.1	1,222	92,284	1.3
Tin	lt	4,685	157	2,984.1	5,152	130	3,963.1
Tungsten (WO_3 content)	lb	1,176,564	4,447,316	26.5	1,019,706	4,640,400[r]	22.0
Zinc	st	134,187[2]	1,252,642[r]	10.7[r]	128,294[r2]	1,352,074	9.5[r]
Nonmetals							
Barite	st	78,900	77,261	102.1	83,148	101,580	81.9
Feldspar	st	9,651	11,684	82.6	6,978	—	. .
Fluorspar	st	232,128	180,000[e]	129.0	215,737	151,000[e]	142.9
Mica	lb	. .	—	. .	. .	—	. .
Nepheline syenite	st	96,112	559,483	17.2	92,009[r]	569,403	16.2[r]
Phosphate rock	st	2,362,010	—	. .	2,430,364	—	. .
Potash (K_2O)[3]	st	274,397	3,852,120	7.1	218,907[r]	4,909,438	4.5[r]
Sodium sulphate	st	429,080	507,275	84.6	300,080	543,354	55.2
Sulphur, elemental	st	689,742[r]	3,635,631	19.0[r]	635,598[r]	4,593,855	13.8[r]
Talc etc.	st	36,253	80,946	44.8	42,287	81,495	51.9
Fuels							
Coal	st	28,393,096	20,709,316	137.1	27,415,021[r]	22,567,349	121.5[r]
Natural gas	mcf	1,145,797,145[4]	2,913,537,215	39.3	1,229,439,641[r4]	3,119,460,755	39.4
Petroleum, crude	bbl	561,992,367[r5]	561,976,934	100.0	611,416,074[5]	655,853,110	93.2

Note: Unless otherwise stated, consumption refers to reported consumption of refined metals or nonmetallic minerals by consumers. Production of metals, in most cases, refers to production in all forms, and includes the recoverable metal content of ores, concentrates, matte, etc., and the metal content of primary products recoverable at domestic smelters and refineries. Production of nonmetals refers to producers' shipments. For fuels, production is equivalent to actual output less waste.
[1]Producers' domestic shipments of refined metal. [2]Includes primary and secondary refined metal. [3]Production and consumption for year ended June 30. [4]Domestic sales. [5]Refinery receipts.
[p]Preliminary; [r]Revised; [e]Estimated; — Nil; . . Not available or not applicable.

and relation to production, 1972-75

1974			1975[p]		
Consumption	Production	Consumption as % of Production	Consumption	Production	Consumption as % of Production
396,602	1,125,329	35.2	. .	977,553	. .
2,168,876	. .	. .	1,001,258	. .	. .
64,547	244,726	26.4	64,522	81,000	. .
105,548	2,735,870	3.9	84,234	2,682,000	. .
66,658	—	. .	40,554	—	. .
408,829	3,447,078	11.9	271,177	2,949,000	9.2
273,356[1]	905,417	30.2	204,142[1]	798,132	25.6
116,070[2]	324,375	35.8	61,134[2]	373,065	. .
6,853	6,566	104.4	5,610	4,961	113.1
232,142	—	. .	177,446	—	. .
83,304	1,064,000	7.8	72,467	. .	. .
3,688,655	30,736,353	12.0	. .	27,414,000	. .
12,750	296,600	4.3	. .	269,826	. .
30,479	599,950	5.1	21,900	670,000	3.3
10,671,283	42,809,721	24.9	. .	40,004,155	. .
981	124,313	0.8	1,354	80,000	1.7
5,339	319	1,673.7	. .	278	. .
1,179,381	3,557,600	33.2	. .	2,987,000	. .
129,653[2]	1,242,314	10.4	164,480[2]	1,193,809	13.8
64,418	86,001	74.9	89,680	. .	. .
7,547	—	. .	. .	—	. .
111,512	180,000[e]	62.0	. .	. .	. .
. .	—	. .	. .	—	. .
95,834	617,279	15.5	. .	520,000	. .
2,533,535	—	. .	. .	—	. .
219,130[r]	6,366,971	3.4	. .	5,346,000	. .
336,608	703,472	47.9	. .	546,000	. .
835,115	5,547,996	15.1	. .	4,476,000	. .
45,334	94,746	47.8	. .	74,000	. .
27,386,605	23,536,000	116.4	. .	27,843,233	. .
1,314,321,000[4]	3,045,506,000	43.2	1,324,705,000[4]	3,074,659,000	43.1
645,583,936[5]	614,777,000	105.0	. . [5]	525,342,000	. .

Table 21. Canada, apparent consumption[1] of some minerals

		1972			1973		
	Unit of Measure	Apparent Consumption	Production	Consumption as a % of Production	Apparent Consumption	Production	Consumption as a % of Production
Asbestos	st	94,956	1,687,051	5.6	−3,696	1,862,976	. .
Cement	st	8,782,660	10,038,617	87.5	9,844,806	11,125,738	88.5
Gypsum	st	2,198,897[r]	8,099,480	27.1	2,138,655	8,389,172	25.5
Iron ore	lt	11,036,181	38,123,627	28.9	12,322,529	46,748,314	26.4
Lime	st	1,476,678[r]	1,744,156	84.7	1,533,756	1,890,590	81.1
Quartz (silica)	st	3,895,112	2,663,836	146.2	3,739,259	2,765,944	135.2
Salt	st	4,218,810[e]	5,416,925	77.9	3,833,670[e]	5,564,627	68.9

[1] Apparent consumption is production plus imports less exports. [2] Production refers to producers' shipments.
[p] Preliminary; . . Not available or not applicable; [r] Revised; [e] Estimated.

and relation to production,[2] 1972-75

		1974			1975^p		
	Unit of Measure	Apparent Consumption	Production	Consumption as a % of Production	Apparent Consumption	Production	Consumption as a % of Production
Asbestos	st	26,840	1,811,938	1.5	33,442	1,143,000	2.9
Cement	st	10,447,523	11,436,398	91.4	10,128,599	10,763,000	94.1
Gypsum	st	2,280,709	7,964,423	28.6	2,246,624	6,255,000	35.9
Iron ore	lt	11,485,518	46,045,611	24.9	13,422,217	44,121,000	30.4
Lime	st	1,606,250	2,009,284	79.9	1,664,142	1,889,000	88.1
Quartz (silica)	st	3,657,239	2,762,028	132.4	3,667,922	2,561,000	143.2
Salt	st	4,382,253^e	6,003,981	73.0	4,529,865^e	5,683,000	79.7

Table 22. Canada, domestic consumption of principal refined metals in relation to refinery production,[1] 1966-75

	Unit of measure	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975[p]
Copper											
Domestic consumption[2]	st	262,557	219,680	250,104	226,281	237,916	221,053	228,907	254,613	273,356	204,142
Production	st	433,004	499,846	524,474	449,232	543,727	526,403	546,685	548,488	616,329	583,342
Consumption of production	%	60.6	43.9	47.7	50.4	43.8	42.0	41.9	46.4	44.4	35.0
Zinc											
Domestic consumption[3]	st	110,481	110,487	118,581	121,420	108,364	114,334	134,187	133,085	129,653	164,480
Production	st	382,605	405,136	426,728	466,357	455,471	410,643	524,885	587,038	469,884	470,622
Consumption of production	%	28.9	27.3	27.8	26.0	23.8	27.8	25.6	22.7	27.6	34.9
Lead											
Domestic consumption[3]	st	96,683	93,953	94,660	105,915	93,437	94,617	86,596	119,082	116,070	61,134
Production	st	184,871	193,235	202,100	187,143	204,630	185,554	205,978	206,012	139,380	189,064
Consumption of production	%	52.3	48.6	46.8	56.6	45.7	51.0	42.0	57.8	83.3	32.3
Aluminum											
Domestic consumption[3]	st	243,301	217,484	242,390	269,027	275,743	322,082	333,550	365,728	396,603	. .
Production	st	889,915	963,343	979,171	1,078,717	1,061,020	1,104,644	1,012,132	1,037,859	1,125,329	977,553
Consumption of production	%	27.3	22.6	24.8	24.9	26.0	29.2	33.0	35.2	35.2	. .

[1] Production of refined metal from all sources, including metal derived from secondary materials at primary refineries.
[2] Producers' domestic shipments of refined metal. [3] Consumption of primary and secondary refined metal, reported by consumers.
[p] Preliminary; . . Not available or not applicable.

Table 23. Average annual prices[1] of main metals, 1971-75

	Unit of measure	1971	1972	1973	1974	1975
Aluminum, major U.S. producer	cents/lb	29.000	26.409	25.000	34.133	39.786
Antimony, RMM/Laredo	cents/lb	69.300	57.000	66.498	179.764	174.575
Bismuth, major producer	$/lb	5.26	3.63	4.92	8.41	7.72
Cadmium, U.S. producer	cents/lb	197.262	255.600	364.000	407,800	335.500
Calcium, metal crowns	$/lb	0.95	0.95	0.95	1.07	1.32
Chrome, U.S. metal, 9% carbon	$/lb	1.56	1.56	1.52	1.90	2.57
Cobalt metal, shot/cathode/ 250 kg	$/lb	2.20	2.45	3.01	3.47	4.00
Columbium, U.S. metallurgical powder	$/lb	11.00-22.00	11.00-22.00	11.00-22.00	. .	. .
Copper, U.S. producer refinery	cents/lb	51.433	50.617	58.852	76.649	63.535
Gold, Royal Canadian Mint buying price	$ Cdn/tr. oz	35.34	36.58	38.86	41.18	43.22
London free market[2]	$ Cdn/tr. oz	41.19	57.53	97.25	155.67	163.74
Iridium, major producer	$/troy oz	150.00-155.00	150.00-178.33	227.08-235.42	401.67-409.17	475.00-485.00
Iron ore						
Bessemer						
Mesabi	$/lt	11.25	11.32	12.01	13.99	. .
Old Range	$/lt	11.51	11.57	12.26	14.24	. .
Non-Bessemer						
Mesabi	$/lt	11.11	11.17	11.86	14.00	17.89
Old Range	$/lt	11.42	11.42	12.13	14.26	18.14
Lead, U.S. producer	cents/lb	13.800	15.029	16.285	22.533	21.529
Manganese, U.S. metal, regular	cents/lb	33.250	33.250	33.250	41.771	54.000
Magnesium, U.S. primary ingot	cents/lb	36.250	37.250	38.250	60.548	82.000
Mercury, New York	$ /flask(76 lb)	292.41	218.28	285.23	281.69	158.12
Molybdenum, red carbon powder	$/lb	4.00	4.00	. .	. .	. .
Molybdenum, climax concentrate	$/lb	1.72	1.72	1.72	2.06	2.49
Nickel, major producer cathode	cents/lb	133.000	139.700	153.000	173.500	207.300
Osmium, major producer	$/troy oz	200.00-225.00	200.00-225.00	200.00-225.00	200.00-225.00	200.00-225.00
Palladium, major producer	$/troy oz	37.00	41.64	77.68	133.22	92.70
Platinum, major producer	$/troy oz	120.52	120.78	150.04	180.85	164.01
Rhenium, U.S. producer powder	$/lb	1,400.00	975.00-1,400.00	887.50-1,050.00	737.50	570.52
Rhodium, major producer	$/troy oz	197.50-202.50	195.00-200.00	225.83-230.83	334.58-342.92	337.50-347.50
Ruthenium, major producer	$/troy oz	50.00-55.00	50.00-55.00	59.17-64.17	60.00-65.00	60.00-65.00
Selenium, major producer commercial	$/lb	9.00	9.00	9.17-10.33	16.33	18.00
Silver, Handy & Harman, New York	cents/troy oz	154.564	168.455	255.756	470.798	441.852

Table 23. (concl'd)

	Unit of measure	1971	1972	1973	1974	1975
Tantalum, U.S. rod	$/lb	36.00-50.00	36.00-50.00	30.00-40.00	41.25-56.17	46.75-60.50
Tellurium, major producer slab	$/lb	6.00	6.00	6.08	8.33	9.33
Tin, New York market	cents/lb	167.348	177.474	227.558	396.266	339.818
Titanium, U.S. sponge	$/lb	1.32	1.32	1.42-1.43	1.85	2.55
Titanium, slag	$/lt	48.00	50.00	50.83	60.00	75.00
Tungsten, U.S. hydrogen red metal	$/lb	5.58-6.84	5.32-6.89	4.97-6.74	8.06-9.75	10.21-12.01
Vanadium,90%,100 lb lots	$/lb	. .	. .	. .	. .	. .
Zinc, U.S. prime western	cents/lb	16.128	17.753	20.658	35.945	38.959

[1]These prices except for gold are in U.S. currency, and are quoted from *Metals Week*. [2]Average of a.m. and p.m. fixings of the London Gold Market, converted to Canadian dollars.
. . Not available or not applicable.

Table 24. Canada, wholesale price indexes of minerals and mineral products, 1972-75 (1935-39=100)

	1972	1973	1974	1975[p]
Iron and products	325.0	354.2	447.7	513.8
Pig iron	317.2	342.7	475.5	748.8
Rolling mill products	315.9	338.8	431.1	499.0
Iron foundries and pipe and tubing	331.8	358.9	452.4	544.0
Wire	382.8	416.3	507.1	620.6
Scrap iron and steel	268.1	388.8	740.6	530.3
Tinplate and galvanized steel	295.0	311.3	357.4	420.2
Nonferrous metal and products				
Total (including gold)	262.9	326.4	417.7	417.4
Total (excluding gold)	388.4	478.5	607.3	606.2
Copper and products	428.0	579.4	706.7	539.8
Lead and products	322.7	366.5	500.1	439.1
Silver	430.6	663.3	1,180.8	1,168.7
Tin	338.8	435.6	764.4	704.4
Zinc and products	419.1	536.8	785.4	842.1
Nonmetallic minerals and products	233.6	255.5	331.2	391.8
Clay and clay products	289.8	308.2	384.2	420.2
Pottery	351.2	439.2	476.0	493.4
Coke	. .	. .	. .	. .
Petroleum products	187.3	226.7	342.0	393.5
Asphalt	229.2	243.9	432.5	516.2
Asphalt shingles	138.1	152.8	189.6	216.9
Plaster	198.0	213.3	247.6	279.0
Lime	347.1	394.5	497.0	624.8
Cement	229.7	233.5	271.6	322.8
Sand and gravel	216.6	234.7	273.1	326.0
Crushed stone	186.5	203.7	236.5	271.2
Building stone	298.3	314.0	336.1	364.8
Asbestos	397.4	414.4	550.8	679.4
General wholesale price index (all products)	310.3	376.9	461.3	491.3

[p]Preliminary; . . Not available or not applicable.

Table 25. Canada, general wholesale price index and wholesale price indexes of mineral and nonmineral products, 1951-75 (1935-39=100)

	Mineral products			Nonmineral products					
	Iron Products	Nonferrous Metal Products	Nonmetallic Mineral Products	Vegetable Products	Animal Products	Textile Products	Wood Products	Chemical Products	General Wholesale Price Index
1951	208.7	180.6	169.8	218.6	297.7	295.9	295.9	187.3	240.2
1952	219.0	172.9	173.9	210.3	248.2	251.5	291.0	180.1	226.0
1953	221.4	168.6	176.9	199.0	241.7	239.0	288.6	175.7	220.7
1954	213.4	167.5	177.0	196.8	236.0	231.1	286.8	176.4	217.0
1955	221.4	187.6	175.2	195.1	226.0	226.2	295.7	177.0	218.9
1956	239.8	199.2	180.8	197.3	227.7	230.2	303.7	180.1	225.6
1957	252.7	176.0	189.3	197.0	238.4	236.0	299.4	182.3	227.4
1958	252.6	167.3	188.5	198.1	250.7	229.0	298.5	183.0	227.8
1959	255.7	174.6	186.5	199.5	254.3	228.0	304.0	187.0	230.6
1960	256.2	177.8	185.6	203.0	247.6	229.8	303.8	188.2	230.9
1961	258.1	181.6	185.2	203.1	254.7	234.5	305.1	188.7	233.3
1962	256.2	192.1	189.1	211.6	262.5	241.2	315.9	190.5	240.0
1963	253.6	197.5	189.5	227.8	255.6	248.0	323.4	189.3	244.6
1964	256.4	205.9	190.9	223.3	250.8	248.4	330.9	191.2	245.4
1965	264.5	217.6	191.6	218.4	270.7	246.4	334.0	200.2	250.3
1966	268.0	229.9	193.7	225.9	296.2	251.5	337.8	207.1	259.5
1967	274.4	240.2	199.2	230.9	293.1	252.7	346.3	212.6	264.1
1968	276.8	250.8	206.0	230.8	294.6	256.5	367.9	213.7	269.9
1969	285.8	264.0	210.0	237.9	322.4	256.7	389.4	219.7	282.4
1970	305.1	281.0	215.7	238.4	326.0	257.0	377.5	225.7	286.4
1971	316.4	260.1	225.8	327.1	326.0	261.9	394.4	237.8	289.9
1972	325.0	262.9	233.6	249.2	371.8	278.3	436.0	245.5	310.3
1973	354.2[r]	326.4[r]	255.5[r]	354.8[r]	455.3	337.8[r]	503.7[r]	263.3	376.9
1974	447.7	417.7	331.2	485.6	493.0	423.1	563.1	325.3	461.3
1975[p]	513.8	417.4	391.8	468.8	537.9	405.4	643.6	383.8	491.3

[r] Revised; [p] Preliminary.

Table 26. Canada, mineral products industries, selling price indexes, 1972-75 (1971=100)

	1972	1973	1974	1975^p
Iron and steel products industries				
Agricultural implements industry	105.0	111.4	128.1	155.1
Hardware, tool and cutlery manufacturers	102.5	106.5	122.2	137.9
Heating equipment manufacturers	104.0	108.2	121.9	137.3
Primary metal industries	102.2	117.5	147.7	160.8
Iron and steel mills	103.2	110.4	136.3	162.1
Steel pipe and tube mills	102.9	111.5	132.0	162.9
Iron foundries	103.0	109.5	141.6	168.4
Wire and wire products manufacturers	104.4	113.9	136.6	158.3
Nonferrous metal products industries				
Aluminum rolling, casting and extruding	100.0	100.5	129.1	145.4
Copper and alloy, rolling, casting and extruding	98.0	122.6	154.8	131.6
Jewelery and silverware manufacturers	109.1	149.4	216.3	234.1
Metal rolling, casting and extruding, nes	104.1	126.5	184.2	171.8
Nonmetallic mineral products industries				
Abrasives manufacturers	99.7	104.3	114.6	140.5
Cement manufacturers	106.4	107.6	122.2	146.3
Clay products manufacturers from imported clay	102.2	106.6	127.3	151.0
Glass and glass products manufacturers	102.7	104.9	114.5	127.1
Lime manufacturers	108.6	116.1	143.5	181.7
Concrete products manufacturers	102.3	109.8	129.7	151.9
Clay products from domestic clay	102.8	111.0	129.1	157.1
Petroleum and coal products industries	102.7	117.2	159.4	183.7
Petroleum refineries	102.7	117.5	160.1	184.5
Lubricating oils	102.3	112.0	132.7	149.8
Mixed fertilizers	102.5	117.2	167.4	204.0

Note: Industry selling price indexes reflect wholesale price trends of products or groups of products sold by the industries listed.
^p Preliminary; nes Not elsewhere specified.

Table 27. Canada, principal statistics of the mining industry,[1] 1973

	Mining activity								Total activity[2]		
	Production and related Workers				Costs						
	Establishments	Employees	Man-hours Paid	Wages	Fuel and Electricity	Materials and Supplies	Value of Production	Value Added	Employees	Salaries and Wages	Value Added
	(number)	(number)	(000)	($000)	($000)	($000)	($000)	($000)	(number)	($000)	($000)
Metals											
Placer gold[3]	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
Gold quartz	21	4,727	9,526	37,438	5,093	30,083	154,341	119,165	5,603	46,097	119,192
Copper-gold-silver	44	12,994	27,738	133,032	32,702	475,094	1,531,371	1,023,575	17,571	185,589	1,026,497
Silver-lead-zinc	21	4,489	9,009	44,082	10,750	196,146	498,602	291,706	6,112	64,501	292,731
Nickel-copper	11	14,696	28,550	149,720	14,766	339,027	1,167,636	813,843	20,031	228,254	820,344
Iron	18	8,521	18,344	104,030	52,823	226,210	632,823	353,790	13,395	173,297	345,830
Misc. metal mines	12	2,557	5,277	26,329	6,385	27,774	139,748	105,588	3,422	35,347	106,713
Total	127	47,984	98,444	494,631	122,519	1,294,334	4,124,521	2,707,667	66,134	733,085	2,711,307
Nonmetals											
Asbestos	12	6,430	14,691	63,229	18,140	53,374	245,920	174,406	8,027	82,027	176,368
Feldspar, quartz and nepheline syenite	13	386	815	3,099	916	3,001	17,898	13,981	479	4,077	13,933
Gypsum	10	575	1,307	4,508	986	3,341	21,123	16,796	676	5,418	16,748
Peat	55	1,081	2,147	5,685	645	4,340	18,508	13,523	1,236	7,015	14,216
Potash	9	2,009	4,111	18,747	9,604	22,946	161,799	129,249	2,684	26,484	128,957
Salt	9	809	1,778	8,106	2,147	8,593	47,128	36,388	1,278	13,051	36,731
Sand and gravel	142	1,631	3,785	14,790	4,272	15,621	75,394	55,500	2,179	20,940	59,841
Stone	112	2,590	6,058	22,523	6,554	29,390	101,612	65,668	3,097	27,064	66,999
Talc and soapstone	4	73	160	446	138	474	2,076	1,464	101	666	1,456
Misc. nonmetals	12	748	1,453	5,894	2,292	2,645	17,638	12,703	910	7,377	12,401
Total	378	16,332	36,305	147,027	45,694	143,725	709,096	519,678	20,667	194,119	527,650
Fuels											
Coal	34	6,445	12,938	60,497	9,115	43,019	216,992	164,858	7,856	75,522	166,705
Petroleum and natural gas	1,087	4,404	9,274	49,723	37,768	70,481	2,979,704	2,871,455	16,786	212,145	2,883,273
Total	1,121	10,849	22,212	110,220	46,883	113,500	3,196,696	3,036,313	24,642	287,667	3,049,978
Total mining industry	1,626	75,165	156,961	751,878	215,096	1,551,559	8,030,313	6,263,658	111,443	1,214,871	6,288,935

[1] Excludes cement manufacturing, lime manufacturers, clay and clay products (domestic clays). These industries are included in the mineral manufacturing industries. Industry coverage is the same as in Tables 29, 31 and 33. [2] Total activity includes sales and head offices. [3] Placer gold no longer surveyed.
. . Not available or not applicable.

Table 28. Canada, principal statistics of the mineral manufacturing industries,[1] 1973

	Mineral manufacturing activity								Total activity[2]		
		Production and related workers			Costs						
	Establishments	Employees	Man-hours Paid	Wages	Fuel and Electricity	Materials and Supplies	Value of Production	Value Added	Employees	Salaries and Wages	Value Added
	(number)	(number)	(000)	($000)	($000)	($000)	($000)	($000)	(number)	($000)	($000)
Primary metal industries											
Iron and steel mills	45	41,202	86,245	438,622	86,745	1,082,758	2,317,520	1,154,569	53,008	595,382	1,169,567
Steel pipe and tube mills	24	4,417	9,734	44,559	5,058	200,196	319,674	117,375	5,288	55,572	115,589
Iron foundries	113	9,305	19,874	82,471	8,552	115,032	284,121	161,217	10,965	101,508	163,711
Smelting and refining	28	23,696	50,591	235,013	99,507	409,079	1,059,648	551,062	32,396	347,573	590,724
Aluminum rolling, casting and extruding	64	4,299	9,550	39,375	5,172	215,732	321,383	95,377	6,206	62,020	94,600
Copper and alloy rolling, casting and extruding	46	3,063	6,783	29,579	3,478	310,236	402,921	91,219	3,736	37,033	91,040
Metal rolling, casting and extruding, nes	83	3,871	7,947	27,734	3,384	131,501	212,726	80,093	4,863	38,812	83,647
Total	403	89,853	190,724	897,353	211,896	2,464,534	4,917,993	2,250,912	116,462	1,237,900	2,308,878
Nonmetallic mineral products industries											
Cement manufacturers	27	2,911	6,321	30,870	39,441	40,226	253,571	171,517	4,871	53,752	172,236
Lime manufacturers	14	559	1,180	4,649	7,497	5,792	31,044	17,858	724	6,354	17,871
Gypsum products manufacturers	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
Concrete products manufacturers	452	8,526	18,407	71,042	8,065	117,589	313,156	191,630	10,790	95,417	197,733
Ready-mix concrete manufacturers	340	7,106	15,328	69,034	11,139	229,588	435,050	195,321	9,233	92,111	202,110
Clay products manufacturers (domestic)	69	2,286	4,969	17,900	6,540	12,608	62,018	41,239	2,826	23,504	41,595
Clay products manufacturers (imported)	35	1,796	3,780	13,520	1,513	14,959	49,858	33,410	2,175	16,983	33,802
Refractories manufacturers	17	801	1,702	6,845	1,837	20,311	47,031	24,652	1,243	11,603	28,075
Stone products manufacturers	88	633	1,328	4,397	442	6,663	17,664	10,898	842	6,261	11,002
Glass and glass products manufacturers	95	10,083	21,204	85,596	14,923	123,928	369,845	230,740	12,840	116,403	235,776
Mineral wool manufacturers	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .

Table 28. (concl'd)

	Mineral manufacturing activity								Total activity[2]		
		Production and related workers			Costs						
	Establishments	Employees	Man-hours Paid	Wages	Fuel and Electricity	Materials and Supplies	Value of Production	Value Added	Employees	Salaries and Wages	Value Added
	(number)	(number)	(000)	($000)	($000)	($000)	($000)	($000)	(number)	($000)	($000)
Asbestos products manufacturers	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .	. .
Abrasives manufacturers	21	1,959	4,279	17,851	9,536	39,353	85,502	37,373	2,555	23,973	38,038
Other nonmetallic mineral products industries	83	4,842	10,703	44,324	8,835	95,994	258,244	154,738	7,850	75,752	171,604
Total	1,241	41,502	89,201	366,028	109,768	707,011	1,922,983	1,109,376	55,949	522,113	1,149,842
Petroleum and coal products industries											
Petroleum refining industry	42	5,947	13,408	76,940	25,960	2,505,051	2,975,852	537,380	14,843	198,766	539,560
Manufacture of lubricating oils and greases	17	299	633	2,608	424	36,891	58,463	21,181	487	4,901	22,410
Other petroleum and coal products industries	46	576	1,247	4,989	1,473	22,042	38,883	15,367	757	6,776	18,725
Total	105	6,822	15,288	84,537	27,857	2,563,984	3,073,198	573,928	16,087	210,443	580,695
Total mineral manufacturing industries	1,749	138,177	295,213	1,347,918	349,521	5,735,529	9,914,174	3,934,216	188,498	1,970,456	4,039,412

[1]Industry coverage is the same as in Tables 30, 32 and 34. [2]Includes sales and head offices.
nes Not elswhere specified; . . Not available or not applicable.

Table 29. Canada, principal statistics of the mining industry,[1] 1968-73

		Mining activity							Total activity[2]		
		Production and related workers			Costs						
	Establishments	Employees	Man-hours Paid	Wages	Fuel and Electricity	Materials and Supplies	Value of Production	Value Added	Employees	Salaries and Wages	Value Added
	(number)	(number)	(000)	($000)	($000)	($000)	($000)	($000)	(number)	($000)	($000)
1968	1,548	75,066	160,346	510,003	119,640	900,344	4,195,930	3,175,945	104,916	772,453	3,189,271
1969	1,686	71,368	151,072	513,708	126,999	931,354	4,400,637	3,342,285	102,088	804,839	3,355,312
1970	1,636	77,208	164,835	614,084	146,049	1,167,456	5,118,396	3,804,891	110,094	994,014	3,830,364
1971	1,662	76,701	158,835	646,900	164,332	1,223,982	5,198,173	3,809,859	110,410	1,015,661	3,826,264
1972	1,716	73,044	150,929	666,505	175,562	1,210,445	5,652,775	4,266,767	107,322	1,068,783	4,292,465
1973	1,626	75,165	156,961	751,878	215,096	1,551,559	8,030,313	6,263,658	111,443	1,214,871	6,288,935

[1]Excludes cement manufacturing, lime manufacturers, clay and clay products (domestic clays). These industries are included in the mineral manufacturing industries. Industry coverage is the same as in Tables 27, 31 and 33. [2]Includes sales and head offices.

Table 30. Canada, principal statistics of the mineral manufacturing industries,[1] 1968-73

		Mineral manufacturing activity							Total activity[2]		
		Production and related workers			Costs						
	Establishments	Workers	Man-Hours Paid	Wages	Fuel and Electricity	Materials and Supplies	Value of Production	Value Added	Employees	Salaries and Wages	Values Added
	(number)	(number)	(000)	($000)	($000)	($000)	($000)	($000)	(number)	($000)	($000)
1968	1,760	130,909	279,988	850,059	227,679	3,537,700	6,264,424	2,530,325	180,324	1,267,968	2,580,192
1969	1,802	128,263	272,947	890,911	232,861	3,689,337	6,581,618	2,677,454	178,474	1,348,463	2,757,052
1970	1,781	131,570	278,547	989,725	263,827	3,954,629	7,002,306	2,849,055	181,620	1,480,524	2,920,381
1971	1,813	131,044	276,629	1,063,861	288,016	4,192,544	7,551,956	3,097,001	181,122	1,595,437	3,166,347
1972	1,783	132,067r	282,307	1,172,977	304,705	4,667,819	8,299,939	3,353,101	182,454	1,753,069	3,436,258r
1973	1,749	138,177	295,213	1,347,918	349,521	5,735,529	9,914,174	3,934,216	188,498	1,970,456	4,039,415

[1]Industry coverage is the same as in Tables 28, 32 and 34. [2]Includes sales and head offices.
r Revised.

Table 31. Canada, consumption of fuel and electricity in the mining industry,[1] 1973

	Unit	Metals	Nonmetals	Fuels	Total
Coal and coke	000 st	44	31	—	75
	$000	917	175	—	1,092
Gasoline	000 gal	5,549	8,400	1,199	15,148
	$000	2,578	3,748	415	6,741
Fuel oil, kerosene, coal oil	000 gal	257,052	82,582	10,762	350,396
	$000	42,880	18,993	2,329	64,202
Liquefied petroleum gas	000 gal	12,173	964	326	13,463
	$000	2,032	277	69	2,378
Natural gas	000 mcf	12,100	19,512	3,408	35,020
	$000	5,971	5,908	1,785	13,664
Other fuels[2]	$000	52	- -	2	54
Total fuels	$000	54,430	29,101	4,600	88,131
Electricity purchased	million kwh	10,032	1,782	2,792	14,606
	$000	68,089	16,593	42,283	126,965
Total value of fuels and electricity purchased, all reporting companies	$000	122,519	45,694	46,883	215,096

[1]Excludes cement and lime manufacturing and manufacture of clay products (domestic clays). These industries are included in mineral manufacturing, Tables 32 and 34. Industry coverage is same as in Tables 27, 29 and 33. [2]Includes wood, manufactured gas, steam purchased and other miscellaneous fuels.
— Nil; - - Amount too small to be expressed.

Table 32. Canada, consumption of fuel and electricity in the mineral manufacturing industries,[1] 1973

	Unit	Primary metals industries	Nonmetallic mineral products industries	Petroleum and coal products industries	Total
Coal and coke	000 st	795	258	3	1,056
	$000	20,353	4,531	8	24,892
Gasoline	000 gal	4,035	15,568	518	20,121
	$000	1,525	7,009	238	8,772
Fuel oil, kerosene, coal oil	000 gal	261,391	249,840	5,337	516,568
	$000	32,749	31,535	959	65,243
Liquefied petroleum gas	000 gal	20,962	2,903	12	23,877
	$000	2,829	808	3	3,640
Natural gas	000 mcf	77,622	58,775	19,540	155,937
	$000	42,036	30,732	6,074	78,842
Other fuels	$000	3,829	529	514	4,872
Total fuels	$000	103,321	75,144	7,796	186,261
Electricity purchased	million kwh	16,584	3,667	2,663	22,914
	$000	108,575	34,624	20,061	163,260
Total value of fuels and electricity purchased, all reporting companies	$000	211,896	109,768	27,857	349,521

[1]Industry coverage is the same as in Tables 28, 30 and 34.

Table 33. Canada, cost of fuel and electricity in the mining industry,[1] 1966-73

	Unit	1966	1967	1968	1969	1970	1971	1972	1973
Metals									
Fuel	$000	22,038	26,116	29,340	27,070	33,370	39,887	40,492	54,430
Electricity purchased	million kwh	5,511	6,300	7,020	7,073	7,995	8,692	8,807	10,032
	$000	35,248	38,342	42,340	46,002	52,257	56,847	58,104	68,089
Value of fuel and electricity used by small establishments[2]	$000	51	24	21	22	21	10	12	. .
Total cost of fuel and electricity	$000	57,337	64,482	71,701	73,094	85,648	96,744	98,608	122,519
Electricity generated for own use and for sale	million kwh	473	510	466	476	459	359	446	. .
Nonmetals[3]									
Fuel	$000	15,410	16,180	18,448	19,793	20,029	22,951	25,277	29,101
Electricity purchased	million kwh	1,022	1,127	1,291	1,473	1,468	1,584	1,642	1,782
	$000	8,867	9,537	10,809	12,728	13,980	14,474	15,080	16,593
Value of fuel and electricity used by small establishments[2]	$000	735	548	342	401	—	—	—	—
Total cost of fuel and electricity	$000	25,012	26,265	29,599	32,922	34,009	37,425	40,357	45,694
Electricity generated for own use and for sale	million kwh	123	151	156	173	161	178	194	. .
Fuels									
Fuels	$000	720	690	678	739	2,072	2,635	4,103	4,600
Electricity purchased	million kwh	955	989	1,101	1,265	1,540	1,763	2,154	2,792
	$000	15,798	16,126	17,662	20,244	23,320	27,528	32,494	42,283
Value of fuel and electricity used by small establishments[2]	$000	—	—	—	—	—	—	—	—
Total cost of fuel and electricity	$000	16,518	16,816	18,340	20,983	26,392	30,163	36,597	46,883
Electricity generated for own use and for sale	million kwh	37	—	—	—	—	—	—	—
Total mining industry									
Fuel	$000	38,168	42,986	48,466	47,602	55,470	65,473	69,872	88,131
Electricity purchased	million kwh	7,488	8,416	9,412	9,811	11,003	12,039	12,603	14,606
	$000	59,913	64,005	70,811	78,974	90,558	98,849	105,678	126,965
Value of fuel and electricity used by small establishments[2]	$000	786	572	363	423	21	10	12	. .
Total cost of fuel and electricity	$000	98,867	107,563	119,640	126,999	146,049	164,332	175,562	215,096
Electricity generated for own use and for sale	million kwh	633	661	622	649	620	537	640	. .

[1]Excludes cement and lime manufacturing and manufacture of clay products (domestic clays). These industries are included in mineral manufacturing, Tables 32 and 34. Industry coverage is same as in Tables 27, 29 and 31. [2]Value of fuel and electricity used by small establishments which have reported in total only. [3]Includes structural materials. . . Not available or not applicable; — Nil.

Table 34. Canada, cost of fuel and electricity used in the mineral manufacturing industries,[1] 1966-73

	Unit	1966	1967	1968	1969	1970	1971	1972	1973
Primary metals									
Fuel	$000	71,129	71,133	73,938	69,185	83,034	92,903	90,850	103,321
Electricity purchased	million kwh	12,531	13,118	14,363	15,370	14,539	15,028	15,678	16,584
	$000	56,774	60,624	68,834	73,114	87,656	90,512	95,447	108,575
Cost of fuel and electricity for small establishments[2]	$000	326	199	171	202	—	—	—	—
Total cost of fuel and electricity	$000	128,229	131,956	142,943	142,501	170,690	183,415	186,297	211,896
Nonmetallic mineral products									
Fuel	$000	45,479	44,055	45,237	47,310	49,451	57,249	65,166	75,144
Electricity purshased	million kwh	3,265	2,987	3,118	3,182	3,270	3,279	2,280	3,667
	$000	20,791	19,962	21,566	23,297	24,507	25,932	29,367	34,624
Cost of fuel and electricity for small establishments[2]	$000	1,122	852	1,165	1,231	—	—	—	—
Total cost of fuel and electricity	$000	67,392	64,869	67,968	71,838	73,958	83,181	94,533	109,768
Petroleum and coal products									
Fuel	$000	3,213	2,980	5,294	5,450	4,749	5,346	6,431	7,796
Electricity purchased	million kwh	1,586	1,659	1,818	1,980	2,171	2,326	2,475	2,663
	$000	10,177	10,699	11,467	13,059	14,430	16,074	17,444	20,061
Cost of fuel and electricity for small establishments[2]	$000	9	15	7	13	—	—	—	—
Total cost of fuel and electricity	$000	13,399	13,694	16,768	18,522	19,179	21,420	23,875	27,857
Total mineral manufacturing industries									
Fuel	$000	119,821	118,168	124,469	121,945	137,234	155,498	162,447	186,261
Electricity purchased	million kwh	17,832	17,764	19,299	20,532	19,980	20,633	20,433	22,914
	$000	87,742	91,285	101,867	109,470	126,593	132,518	142,258	163,260
Cost of fuel and electricity for small establishments[2]	$000	1,457	1,066	1,343	1,446	—	—	—	—
Total cost of fuel and electricity	$000	209.020	210,519	227,679	232,861	263,827	288,016	304,705	349,521

[1]Industry coverage is the same as in Tables 28, 30 and 32. [2]Total cost of fuel and electricity purchased by small establishments, without detail.
— Nil.

Table 35. Canada, employment, salaries and wages in the mining industry,[1] 1966-73

	Unit	1966	1967	1968	1969	1970	1971	1972	1973
Metals									
Production and related workers	number	48,276	48,262	49,238	46,023	51,102	50,121	46,257	47,984
Salaries and wages	$000	284,477	317,978	350,321	341,495	421,893	434,222	430,919	494,631
Annual average salary and wage	$	5,893	6,589	7,115	7,420	8,256	8,663	9,316	10,308
Administrative and office workers	number	13,394	13,466	14,131	14,527	15,488	15,891	15,737	18,150
Salaries and wages	$000	100,666	111,405	124,451	137,756	158,653	178,640	189,669	238,454
Annual average salary and wage	$	7,516	8,273	8,807	9,482	10,244	11,242	12,052	13,138
Total metals									
Employees	number	61,670	61,728	63,369	60,550	66,590	66,012	61,994	66,134
Salaries and wages	$000	385,143	429,383	474,772	479,251	580,546	612,862	620,588	733,085
Annual average salary and wage	$	6,245	6,956	7,492	7,915	8,718	9,284	10,010	11,085
Nonmetals									
Production and related workers	number	14,916	15,049	15,458	15,933	16,245	16,155	15,911	16,332
Salaries and wages	$000	77,984	84,755	94,850	107,622	114,345	122,355	131,372	147,027
Annual average salary and wage	$	5,228	5,632	6,135	6,754	7,039	7,574	8,257	9,002
Administrative and office workers	number	3,818	3,807	4,051	4,081	4,415	4,278	4,109	4,335
Salaries and wages	$000	26,049	28,397	32,836	34,980	39,533	40,222	43,030	47,092
Annual average salary and wage	$	6,823	7,459	8,106	8,573	8,954	9,402	10,472	10,863
Total nonmetals									
Employees	number	18,734	18,856	19,509	20,014	20,660	20,433	20,020	20,667
Salaries and wages	$000	104,033	113,152	127,686	142,602	153,878	162,577	174,402	194,119
Annual average salary and wage	$	5,553	6,000	6,545	7,125	7,448	7,957	8,711	9,393
Fuels									
Production and related workers	number	11,003	10,919	10,370	9,412	9,861	10,425	10,876	10,849
Salaries and wages	$000	57,035	62,756	64,832	64,591	77,846	90,324	104,214	110,220
Annual average salary and wage	$	5,184	5,747	6,252	6,862	7,894	8,664	9,582	10,159
Administrative and office workers	number	10,656	11,175	11,668	12,112	12,983	13,540	14,432	13,793
Salaries and wages	$000	83,021	95,387	105,163	118,395	131,744	149,898	169,579	177,447
Annual average salary and wage	$	7,791	8,536	9,013	9,775	10,147	11,070	11,750	12,865
Total fuels									
Employees	number	21,659	22,094	22,038	21,524	22,844	23,965	25,308	24,642
Salaries and wages	$000	140,056	158,143	169,995	182,986	209,590	240,222	273,793	287,667
Annual average salary and wage	$	6,466	7,158	7,714	8,501	9,175	10,024	10,818	11,674

Table 35. (concl'd)

	Unit	1966	1967	1968	1969	1970	1971	1972	1973
Total mining									
Production and related workers	number	74,195	74,230	75,066	71,368	77,208	76,701	73,044	75,165
Salaries and wages	$000	419,496	465,489	510,003	513,708	614,084	646,900	666,505	751,878
Annual average salary and wage	$	5,654	6,271	6,794	7,198	7,954	8,434	9,125	10,003
Administrative and office workers	number	27,868	28,448	29,850	30,720	32,886	33,709	34,278	36,278
Salaries and wages	$000	209,736	235,189	262,450	291,131	329,930	368,760	402,278	462,993
Annual average salary and wage	$	7,526	8,267	8,792	9,477	10,033	10,940	11,736	12,762
Total mining									
Employees	number	102,063	102,678	104,916	102,088	110,094	110,410	107,322	111,443
Salaries and wages	$000	629,232	700,678	772,453	804,839	944,014	1,015,661	1,068,783	1,214,871
Annual average salary and wage	$	6,165	6,824	7,363	7,883	8,575	9,199	9,959	10,901

[1]According to the revised Standard Industrial Classification. Does not include cement and lime manufacturing and clay products (domestic clays) manufacturing. These industries are included in Table 36 under "Nonmetallic mineral products industries."
See Table 27 for detail of industries covered.

Table 36. Canada, employment, salaries and wages in the mineral manufacturing industries,[1] 1966-73

	Unit	1966	1967	1968	1969	1970	1971	1972	1973
Primary metal industries									
Production and related workers	number	87,748	86,784	86,237	83,564	88,839	86,452	86,335	89,853
Salaries and wages	$000	518,347	541,970	570,183	583,498	680,779	714,600	781,209	897,353
Annual average salary and wage	$	5,907	6,245	6,612	6,982	7,663	8,266	11,051	9,987
Administrative and office workers	number	22,555	23,294	26,786	27,389	27,706	27,862	27,623	26,609
Salaries and wages	$000	169,686	185,800	233,273	255,548	277,728	303,113	327,598	340,547
Average annual salary and wage	$	7,523	7,976	8,709	9,330	10,024	10,879	11,860	12,798
Total primary metal industries									
Employees	number	110,303	110,078	113,023	110,953	116,545	114,314	113,958	116,462
Salary and wages	$000	688,033	727,770	803,456	839,046	958,507	1,017,713	1,108,807	1,237,900
Annual average salary and wage	$	6,238	6,611	7,109	7,562	8,224	8,903	9,730	10,629
Nonmetallic mineral products industries									
Production and related workers	number	39,561	37,467	37,796	38,107	36,045	38,035	39,159	41,502
Salaries and wages	$000	206,120	207,204	223,173	246,196	244,201	281,046	316,033	366,028
Annual average salary and wage	$	5,210	5,569	5,919	6,461	6,775	7,389	8,071	8,820
Administrative and office workers	number	11,583	11,793	13,874	13,781	13,383	13,256	13,928	14,447
Salaries and wages	$000	73,851	79,464	102,869	111,568	117,163	124,085	142,193	155,585
Annual average salary and wage	$	6,376	6,738	7,415	8,096	8,754	9,361	10,209	10,769
Total nonmetallic mineral products									
Employees	number	51,144	49,260	51,670	51,888	49,428	51,291	53,087	55,949
Salaries and wages	$000	279,971	286,668	326,042	357,764	361,364	405,131	458,226	522,113
Annual average salary and wage	$	5,474	5,819	6,310	6,895	7,311	7,899	8,632	9,332
Petroleum and coal products industries									
Production and related workers	number	6,832	6,839	6,876	6,590	6,686	6,557	6,583	6,822
Salaries and wages	$000	48,780	52,462	56,703	61,217	64,745	68,215	75,735	84,537
Annual average salary and wage	$	7,140	7,671	8,247	9,289	9,684	10,403	11,505	12,392
Administrative and office workers	number	3,173	3,264	8,755	9,043	8,961	8,960	8,826	9,265
Salaries and wages	$000	26,540	28,287	81,767	90,436	95,908	104,378	110,301	125.906
Annual average salary and wage	$	8,364	8,666	9,339	10,001	10,703	11,649	12,497	13,589
Total petroleum and coal products									
Employees	number	10,005	10,103	15,631	15,633	15,647	15,517	15,409	16,087
Salaries and wages	$000	75,320	80,749	138,470	151,653	160,653	172,593	186,036	210,443
Annual average salary and wage	$	7,528	7,993	8,859	9,701	10,267	11,123	12,073	13,082

Table 36. (concl'd)

	Unit	1966	1967	1968	1969	1970	1971	1972	1973
Total mineral manufacturing industries									
Production and related workers	number	134,141	131.090	130,909	128,263	131,570	131,044	132,077	138,177
Salaries and wages	$000	773,247	801,636	850,059	890,911	989,725	1,063,861	1,172,977	1,347,918
Annual average salary and wage	$	5,764	6,115	6,494	6,945	7,522	8,118	8,881	9,755
Administrative and office workers	number	37,311	38,351	49,415	50,211	50,050	50,078	50,377	50,321
Salaries and wages	$000	270,077	293,551	417,909	457,552	490,799	531,576	580,092	622,038
Annual average salary and wage	$	7,239	7,654	8,457	9,113	9,806	10,615	11,515	12,361
Total mineral manufacturing industries									
Employees	number	171,452	169,441	180,324	178,474	181,620	181,122	182,454	188,498
Salaries and wages	$000	1,043,324	1,095,187	1,267,968	1,348,463	1,480,524	1,595,437	1,753,069	1,970,456
Annual average salary and wage	$	6,085	6,464	7,032	7,556	8,151	8,809	9,608	10,454

[1]See footnote, Table 35. See Table 28 for detail of industries covered.

Table 37. Canada, number of wage earners, surface, underground and mill, mining industry,[1] 1970-73

	1970	1971	1972	1973
Metals				
Surface	14,724	14,316	13,171	15,060
Underground	25,317	24,907	22,177	20,336
Mill	11,061	10,898	10,909	12,588
Total	51,102	50,121	46,257	47,984
Nonmetals				
Surface	7,515	7,650	6,952	7,080
Underground	1,954	1,733	1,792	1,881
Mill	6,776	6,772	7,167	7,383
Total	16,245	16,155	15,911	16,344
Fuels				
Surface	5,091	5,798	7,576	7,820
Underground	4,770	4,627	3,300	3,029
Total	9,861	10,425	10,876	10,849
Total mining industry				
Surface	27,330	27,764	27,699	29,960
Underground	32,041	31,267	27,269	25,246
Mill	17,837	17,670	18,076	19,971
Total	77,208	76,701	73,044	75,177

[1]See Table 27 for detail of industry coverage.

Table 38. Canada, labour costs in relation to tons mined, metal mines, 1971-73

Type of metal mine	Number of wage earners	Total wages	Average annual wage	Tons of ore mined	Average annual tons mined per wage earner	Wage cost per ton mined
		($000)	($)	(000 st)	(st)	($)
1973						
Auriferous quartz[1]	4,727	37,438	7,920	6,463	1,367	5.79
Copper-gold-silver	12,994	133,032	10,238	116,924	8,998	1.14
Nickel-copper	14,696	149,720	10,188	25,538	1,738	5.86
Silver-cobalt[2]	. .	. .	. .	. .	. .	. .
Silver-lead-zinc	4,489	44,082	9,820	16,934	3,772	2.60
Iron ore	8,521	104,030	12,209	119,735	14,052	0.87
Miscellaneous metals	2,557	26,329	10,297	17,292	6,763	1.52
Total	47,984	494,631	10,308	302,886	6,312	1.63
1972						
Auriferous quartz	4,663	32,902ʳ	7,056	6,713	1,440	4.90
Copper-gold-silver	12,449	115,684	9,293	73,422	5,898	1.58
Nickel-copper	15,310	146,519	9,570	25,459	1,663	5.75
Silver-cobalt	125	964	7,712	135	1,080	7.14
Silver-lead-zinc	4,391	38,490	8,766	15,603	3,553	2.47
Iron ore	6,693	70,695	10,563	91,747	13,708	0.77
Miscellaneous metals	2,626	25,664	9,773	13,965	5,318	1.84
Total	46,257	430,918ʳ	9,316	227,044	4,908	1.90
1971						
Auriferous quartz	5,138	32,571	6,339	7,337ʳ	1,428	4.44
Copper-gold-silver	11,868	100,358	8,456	47,837	4,031	2.10
Nickel-copper	17,664	159,779	9,045	34,484	1,952	4.63
Silver-cobalt	228	1,637	7,180	165	724	9.92
Silver-lead-zinc	4,640	39,224	8,453	16,186	3,488	2.42
Iron ore	7,493	72,172	9,632	107,222	14,310	0.67
Miscellaneous metals	3,090	28,482ʳ	9,217	19,876	6,432	1.43
Total	50,121	434,223ʳ	8,663	233,107ʳ	4,651	1.86

[1] Placer gold mines no longer surveyed. [2] Included with silver-lead-zinc mines.
. . Not available or not applicable; ʳRevised

Table 39. Canada, man-hours paid, production and related workers, tons of ore mined and rock quarried, metal mines and nonmetallic mineral operations, 1967-73

	Unit	1967	1968	1969	1970	1971	1972	1973
Metal mines[1]								
Ore mined	million st	186.5	206.1	189.6	234.9	233.1	227.0	302.9
Man-hours paid[2]	million	103.8	105.2	95.8	108.2	102.1	93.8	98.4
Man-hours paid per ton mined	number	0.56	0.51	0.51	0.46	0.44	0.41	0.32
Tons mined per man-hour paid	st	1.80	1.96	1.98	2.17	2.28	2.42	3.08
Nonmetallic mineral operations[3]								
Ore mined and rock quarried	million st	177.9	173.4	179.9	178.1ʳ	182.9	186.7ʳ	210.0
Man-hours paid[2]	million	25.3	25.9	28.4	28.6	27.5	27.4	28.6
Man-hours paid per ton mined	number	0.14	0.15	0.16	0.16	0.15	0.15	0.14
Tons mined per man-hour paid	st	7.04	6.69	6.33	6.22	6.65	6.81ʳ	7.34

[1]Excludes placer mining. [2]Man-hours paid for production and related workers only. [3]Excludes salt, cement, clay products, stone for cement and lime manufacture, and peat.
ʳ Revised.

Table 40. Canada, basic wage rates per hour in metal mining industry on October 1, 1974 and October 1, 1975

	Gold mines[1]		Iron mines[2]		Other metal mines[3]	
	1974	1975[p]	1974	1975[p]	1974	1975[p]
			($)			
Underground workers						
Cageman	5.14	5.69	. .	. .	4.61	5.27
Car dropper	. .	. .	. .	. .	4.44	5.42
Dinkey-engine operator	. .	. .	. .	. .	4.41	5.55
Grizzly worker	. .	. .	. .	. .	4.64	5.55
Hoist operator	5.18	5.85	. .	. .	5.04	5.59
Labourer	5.06	5.38	. .	. .	4.34	5.09
Mechanical shovel operator	5.10	5.46	. .	. .	4.76	5.27
Miner, "all-round"	4.79	5.56	. .	. .	4.60	5.43
Miner's helper	. .	5.57	. .	. .	4.34	4.95
Timber and steel-prop setter	5.11	. .	. .	. .	4.60	5.15
Track repairman	. .	. .	. .	. .	4.27	5.31
Open pit workers						
Blaster	. .	. .	5.21	6.51	. .	. .
Bulldozer operator	. .	. .	5.03	6.19	. .	. .
Driller machine operator	. .	. .	5.23	6.77	. .	. .
Dumptruck driver	. .	. .	5.37	6.56	. .	. .
Oiler and greaser	. .	. .	4.50	5.95	. .	. .
Shovel operator (power)	. .	. .	5.60	7.02	. .	. .
Surface and mill workers						
Bit-sharpener tender	5.07	. .	. .	. .	4.66	5.45
Blacksmith	. .	. .	. .	. .	5.20	6.22
Carpenter, maintenance	4.76	. .	5.51	6.81	5.36	6.42
Crusher tender	4.99	5.70	5.02	6.36	4.47	5.41
Diesel mechanic	. .	. .	5.76	7.14	5.70	6.66
Electrical repairman	4.85	. .	5.88	7.14	5.54	6.62
Filtering attendant	. .	. .	. .	. .	4.41	5.28
Flotation-cell tender	. .	. .	. .	. .	4.74	5.46
Grinder and classifier tender	. .	. .	5.40	6.62	4.68	5.36
Labourer	4.20	. .	4.20	5.30	4.43	5.01
Leaching operator	. .	. .	. .	. .	. .	. .
Maintenance machinist	4.90	. .	5.85	7.24	5.63	6.51
Maintenance-man helper	. .	5.23	4.91	. .	. .	5.31
Millman[4]	5.10	. .	. .	. .	. .	. .
Millwright	. .	. .	5.75	7.02	5.47	6.63
Pipefitter, maintenance	4.58	. .	5.17	6.80	5.45	6.46
Truckdriver, light and heavy	4.65	. .	4.88	6.23	4.98	5.66
Welder, maintenance	4.84	. .	5.66	7.01	5.63	6.51

[1]Figures from Quebec and Ontario only. [2]Figures from Newfoundland, Ontario, Quebec and British Columbia. [3]Figures from Quebec, Ontario and British Columbia. [4]Includes filtering attendant, grinder and classifier and leaching operator.
[p]Preliminary; . . Not available or not applicable.

Table 41. Canada, average weekly wages and hours worked, hourly-rated employees in mining, manufacturing and construction industries, 1968-75

	1968	1969	1970	1971	1972	1973	1974	1975[p]
Mining								
Average hours per week	41.8	41.4	41.0	40.4	40.3	40.9	40.4	40.0
Average weekly wage ($)	128.28	135.94	152.10	163.22	174.94	196.89	225.25	260.64
Metals								
Average hours per week	41.2	40.7	40.3	39.3	39.0	39.6	39.4	39.4
Average weekly wage ($)	131.55	137.68	154.68	164.27	174.69	195.89	222.80	260.15
Mineral fuels								
Average hours per week	41.9	41.9	42.0	41.4	41.0	41.0	40.6	39.7
Average weekly wage ($)	109.96	122.88	146.68	161.46	176.36	198.08	231.51	265.35
Nonmetals								
Average hours per week	42.4	41.9	41.3	41.4	41.3	41.3	41.1	40.1
Average weekly wage ($)	121.24	129.05	139.21	151.52	158.30	173.10	191.51	230.54
Manufacturing								
Average hours per week	40.3	40.0	40.0	40.3	40.4	39.6	38.9	38.6
Average weekly wage ($)	104.00	111.69	119.69	130.22	141.53	152.77	170.03	195.07
Construction								
Average hours per week	40.5	39.8	39.2	39.2	40.1	39.5	38.9	39.0
Average weekly wage ($)	134.84	146.90	165.04	186.20	206.43	223.86	251.08	293.44

[p] Preliminary.

Table 42. Canada, average weekly wages of hourly-rated employees in the mining industry, in current and 1961 dollars, 1968-75

	1968	1969	1970	1971	1972	1973	1974	1975[p]
Current dollars								
All mining	128.28	135.94	152.10	163.22	174.94	196.89	222.25	260.64
Metals	131.55	137.68	154.68	164.27	174.69	195.89	222.80	260.15
Gold	101.26	107.69	113.72	124.61	131.92	151.73	192.78	220.15
Mineral fuels	109.96	122.88	146.68	161.46	176.36	198.08	231.51	265.35
Coal	97.41	108.58	130.37	144.26	158.18	181.29	212.56	243.31
Nonmetals except fuel	121.24	129.05	139.21	151.52	158.30	173.10	191.51	230.54
1961 dollars								
All mining	106.81	108.32	117.27	122.35	125.14	130.91	133.24	141.05
Metals	109.53	109.71	119.26	123.14	124.96	130.25	133.57	140.78
Gold	84.31	85.81	87.68	93.41	94.36	100.88	115.58	119.14
Mineral fuels	91.56	97.91	113.09	121.03	126.15	131.70	138.79	143.60
Coal	81.11	86.52	100.52	108.14	113.15	120.54	127.43	131.67
Industrial minerals	100.95	102.83	107.33	113.58	113.23	115.09	114.81	124.76

[p] Preliminary.

Table 43. Canada, industrial fatalities per thousand workers, by industry groups, 1973-75

	Fatalities (number)			Number of workers (000)			Rate per 1,000 workers		
	1973	1974	1975	1973	1974	1975	1973	1974	1975[p]
Agriculture	25	36	12	467	473	479	0.06	0.08	0.03
Forestry	94	85	69	80	82	72	1.18	1.04	0.96
Fishing	15	11	19	25	24	23	0.60	0.45	0.83
Mining[1]	166	204	149	123	126	132	1.35	1.62	1.13
Manufacturing	234	303	202	1,968	2,024	1,951	0.12	0.15	0.10
Construction	201	250	197	549	598	605	0.37	0.42	0.33
Transportation	241	257	174	773	790	806	0.31	0.33	0.22
Trade	78	128	60	1,498	1,575	1,633	0.05	0.08	0.04
Finance	6	6	3	410	446	460	0.02	0.01	0.01
Service	78	118	73	2,284	2,386	2,508	0.03	0.05	0.03
Public administration	89	67	86	582	613	639	0.15	0.11	0.13
Total	1,227	1,465	1,044	8,759	9,137	9,308	0.14	0.16	0.11

Note: See footnotes, Table 44.
[1] Includes fatalities resulting from occupational chest diseases such as silicosis, lung cancer, etc. In 1975, 81 fatalities of this type were reported.
[p] Preliminary.

Table 44. Canada, industrial fatalities per thousand workers, by industry groups, 1965-1975

	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975[p]
Agriculture	0.08	0.10	0.05	0.05	0.06	0.03	0.04	0.06	0.06	0.08	0.03
Forestry	1.40	1.45	1.25	1.28	1.10	1.31	1.29	1.07	1.18	1.04	0.96
Fishing[1]	1.74	1.42	1.32	0.79	0.86	1.25	0.50	0.45	0.60	0.45	0.83
Mining[2]	1.31	1.21	1.61	1.15	1.40	1.20	1.26	1.38	1.35	1.62	1.13
Manufacturing	0.14	0.13	0.11	0.10	0.11	0.10	0.10	0.13	0.12	0.15	0.10
Construction	0.60	0.59	0.43	0.46	0.49	0.41	0.45	0.42	0.37	0.42	0.33
Transportation[3]	0.47	0.40	0.34	0.26	0.30	0.27	0.29	0.31	0.31	0.33	0.22
Trade	0.06	0.05	0.05	0.05	0.05	0.05	0.06	0.05	0.05	0.08	0.04
Finance[4]	0.01	0.00	0.02	0.00	0.01	0.01	0.01	0.02	0.02	0.01	0.01
Service[5]	0.03	0.03	0.03	0.02	0.03	0.03	0.03	0.05	0.03	0.05	0.03
Public administration	0.13	0.07	0.08	0.14	0.14	0.16	0.13	0.11	0.15	0.11	0.13
Total	0.19	0.17	0.15	0.13	0.14	0.13	0.14	0.15	0.14	0.16	0.11

[1]Includes trapping, hunting. [2]Includes quarrying and oil wells. [3]Includes storage, communication, electric power and water utilities. [4]Includes insurance and real estate. [5]Includes community, business and personal service.
[p]Preliminary.

Table 45. Canada, number of strikes and lockouts, by industries, 1974-75

	1974			1975[p]		
	Strikes and lockouts	Workers involved	Duration in man-days	Strikes and lockouts	Workers involved	Duration in man-days
Agriculture	1	503	2,450	—	—	—
Forestry	16	16,065	204,770	9	1,825	48,600
Fishing and trapping	7	5,114	102,220	3	4,394	96,430
Mines	61	30,735	515,250	44	32,906	1,173,040
Manufacturing	685	232,436	4,814,560	480	153,963	5,624,710
Construction	72	154,856	2,409,980	111	56,887	1,064,580
Transportation and utilities	127	73,352	700,020	103	71,961	1,462,120
Trade	77	9,634	118,970	73	19,046	334,720
Finance, insurance and real estate	6	107	2,010	5	2,075	145,390
Service	104	32,619	272,060	145	58,948	760,670
Public administration	60	36,799	112,830	80	26,641	331,230
All industries	1,216	592,220	9,255,120	1,053	428,646	11,041,490

[p]Preliminary; — Nil.

Table 46. Canada, ore mined and rock quarried in the mining industry, 1971-73

	1971	1972	1973
		(short tons)	
Metals			
Gold quartz	7,337,407	6,712,618	6,462,837
Copper-gold-silver	47,837,400	73,422,266	116,924,379
Silver-cobalt	164,690	134,814	119,466
Silver-lead-zinc	16,185,964	15,602,662	16,815,135
Nickel-copper	34,484,304	25,459,441	25,538,412
Iron	107,221,930	91,746,947	119,734,745
Miscellaneous metals	19,876,406	13,964,991	17,291,605
Total	233,108,101	227,043,739	302,886,579
Nonmetals			
Asbestos	84,475,059	79,179,897	88,811,484
Feldspar, nepheline syenite	706,240	686,562	686,059
Quartz (excluding sand)	1,495,943	1,325,357	1,555,873
Gypsum	6,735,651	8,042,115	8,398,711
Talc, soapstone	73,851	86,654	94,182
Rock salt	4,581,429	4,622,532	4,525,138
Other nonmetallics	15,893,105	17,159,472	18,213,353
Total	113,961,278	111,102,589	122,284,800
Structural materials			
Stone, all kinds quarried	73,514,842	80,202,524	92,274,188
Stone used to make cement	14,367,599	14,650,285	16,469,970
Stone used to make lime	2,973,392	3,219,070	3,517,254
Total	90,855,833	98,071,879	112,261,412
Total ore mined and rock quarried	437,925,212	436,218,207	537,432,791

Table 47. Canada, ore mined and rock quarried in the mining industry, 1939-73

	Metals	Nonmetals[1]	Total
		(million short tons)	
1939	35.9	16.5	52.4
1940	39.6	20.3	59.9
1941	43.0	21.6	64.6
1942	42.5	21.7	64.2
1943	38.7	20.7	59.4
1944	35.3	19.3	54.6
1945	31.3	20.6	51.9
1946	28.9	24.8	53.7
1947	33.3	30.4	63.7
1948	36.9	33.5	70.4
1949	43.3	32.9	76.2
1950	45.9	41.8	87.7
1951	48.8	43.8	92.6
1952	52.3	44.2	96.5
1953	54.4	47.2	101.6
1954	59.0	61.5	120.5
1955	69.2	63.5	132.7
1956	77.4	73.0	150.4
1957	84.3	82.2	166.5
1958	78.8	78.5	157.3
1959	99.1	90.7	189.8
1960	101.6	97.8	199.4
1961	99.4	106.7	206.1
1962	114.3	114.5	228.8
1963	124.3	132.8	257.1
1964	141.1	147.8	288.9
1965	166.5	161.5	328.0
1966	162.8	189.4	352.2
1967	186.5	195.7	382.2
1968	206.1	190.3	396.4
1969	189.6	197.1	386.7
1970	234.9	197.3	432.2
1971	233.1	204.8	437.9
1972	227.0	209.2	436.2
1973	302.9	234.5	537.4

[1]Includes nonmetallic mineral mining and all stone quarried, including stone used to make cement and lime. Excludes coal. Coverage is the same as in Table 46.

Table 48. Canada, exploration and capital expenditures in the mining industry,[1] by provinces and territories, 1973-75

		Capital						Repair						
		Construction												
		On-Property Exploration	On-Property Development	Structures	Total	Machinery and Equipment	Total Capital	Construction	Machinery and Equipment	Total Repair	Total Capital and Repair	Outside or General Exploration	Land and Mining Rights	Total all Expenditures
		($ million)												
Atlantic Provinces	1973	2.0	11.6	26.1	39.7	58.9	98.6	10.1	66.1	76.2	174.8	4.5	0.2	179.5
	1974	1.7	19.7	26.8	48.2	29.9	78.1	16.7	96.9	113.6	191.7	10.1	. .	. .
	1975p	2.0	26.0	36.7	64.7	36.0	100.7	5.5	116.3	121.8	222.5	13.2	0.5	236.2
Quebec	1973	3.1	45.1	130.6	178.8	151.0	329.8	7.7	102.7	110.4	440.2	13.4	. .	. .
	1974	6.3	59.4	126.6	192.3	68.5	260.8	10.6	138.5	149.1	409.9	21.4	2.6	433.9
	1975p	4.5	72.8	163.8	241.1	101.4	342.5	11.9	142.4	154.3	496.8	25.2	. .	. .
Ontario	1973	6.9	70.6	13.3	90.8	45.8	136.6	19.2	115.6	134.8	271.4	18.5	2.5	292.4
	1974	7.1	73.2	44.6	124.9	70.9	195.8	17.3	122.7	140.0	335.8	19.6	3.1	358.5
	1975p	8.3	98.6	52.3	159.2	84.6	243.8	25.3	141.0	166.3	410.1	22.8	. .	. .
Manitoba	1973	. .	. .	. .	26.1	9.3	35.4	2.4	21.1	23.5	58.9	5.9	. .	. .
	1974	. .	. .	. .	15.7	7.8	23.5	2.7	26.7	29.4	52.9	6.9	0.1	59.9
	1975p	. .	. .	. .	20.7	13.9	34.6	1.8	37.8	39.6	74.2	5.9	—	80.1
Saskatchewan	1973	. .	. .	. .	12.2	14.7	26.9	1.3	26.7	28.0	54.9	6.3	. .	. .
	1974	. .	. .	. .	30.3	23.4	53.7	7.0	33.5	40.5	94.2	6.3	0.1	100.6
	1975p	. .	. .	. .	22.4	71.6	94.0	11.3	38.4	49.7	143.7	9.7	0.3	153.7
Alberta	1973	. .	. .	. .	12.3	3.4	15.7	0.4	6.1	6.5	22.2	2.5	. .	. .
	1974	. .	. .	. .	18.7	20.7	39.4	0.4	9.2	9.6	49.0	4.1	1.2	54.3
	1975p	. .	. .	. .	18.2	33.6	51.8	2.3	15.2	17.5	69.3	3.6	0.3	73.2
British Columbia	1973	5.6	20.2	16.1	41.9	32.1	74.0	10.9	80.7	91.6	165.6	27.0	1.4	194.0
	1974	3.8	37.9	31.3	73.0	54.1	127.1	12.8	106.7	119.5	246.6	22.5	1.0	270.1
	1975p	4.7	30.8	19.6	55.1	62.0	117.1	10.8	124.3	135.1	252.2	24.5	2.2	278.9
Yukon and Northwest Territories	1973	2.0	14.1	6.7	22.8	5.8	28.6	2.5	15.9	18.4	47.0	9.0	0.4	56.4
	1974	2.2	13.0	7.3	22.5	8.3	30.8	4.3	16.2	20.5	51.3	19.9	. .	. .
	1975p	2.8	11.4	15.2	29.4	22.9	52.3	7.9	24.9	32.8	85.1	23.9	0.4	109.4
Canada	1973	23.2	184.6	216.8	424.6	321.0	745.6	54.5	434.9	489.4	1,235.0	87.1	9.1	1,331.2
	1974	25.2	228.6	271.8	525.6	283.6	809.2	71.8	550.4	622.2	1,431.4	110.8	20.2	1,562.4
	1975p	26.1	274.9	309.8	610.8	426.0	1,036.8	76.8	640.3	717.1	1,753.9	128.8	11.3	1,894.0

[1] Excludes the petroleum and natural gas industries and the smelting and refining industries. Industry coverage is the same as in Table 49.
. . Not available or not applicable; p Preliminary; — Nil.

Table 49. Canada, exploration and capital expenditures[1] in the mining industry, by type of mining, 1973-75

		Capital: Construction: On-Property Exploration	Capital: Construction: On-Property Development	Capital: Construction: Structures	Capital: Construction: Total	Capital: Machinery and Equipment	Total Capital	Repair: Construction	Repair: Machinery and Equipment	Total Repair	Total Capital and Repair	Outside or General Exploration	Land and Mining Rights	Total all Expenditures
		($ million)												
Metal mining														
Gold	1973	1.0	10.7	1.8	13.5	3.4	16.9	0.4	4.6	5.0	21.9	1.0	0.1	23.0
	1974	1.9	19.4	3.2	24.5	5.9	30.4	1.2	8.5	9.7	40.1	1.9	0.3	42.3
	1975^p	1.7	17.5	1.4	20.6	5.3	25.9	0.8	10.9	11.7	37.6	1.6	—	39.2
Copper-gold -silver	1973	6.2	45.9	26.1	78.2	64.9	143.1	12.9	83.0	95.9	239.0	6.2	0.2	245.4
	1974	5.0	51.0	41.7	97.7	66.7	164.4	14.7	108.7	123.4	287.8	3.3	—	291.1
	1975^p	6.5	54.2	47.9	108.6	51.8	160.4	10.3	125.1	135.4	295.8	5.2	0.7	301.7
Silver-lead -zinc	1973	2.9	14.5	8.5	25.9	13.9	39.8	3.0	17.4	20.4	60.2	1.3	—	61.5
	1974	3.2	17.8	17.9	38.9	13.8	52.7	5.6	19.3	24.9	77.6	3.8	—	81.4
	1975^p	4.1	25.0	26.3	55.4	29.3	84.7	7.2	23.7	30.9	115.6	3.5	—	119.1
Iron	1973	. .	. .	. .	170.1	136.8	306.9	14.4	117.9	132.3	439.2	1.5	—	440.7
	1974	. .	. .	. .	159.0	40.7	199.7	21.5	171.9	193.4	393.1	1.8	0.1	395.0
	1975^p	. .	. .	. .	225.3	84.8	310.1	9.8	201.4	211.2	521.3	1.5	—	522.8
Other metal mining	1973	. .	. .	. .	66.3	21.1	87.4	17.3	76.6	93.9	181.3	5.7	0.1	187.1
	1974	. .	. .	. .	85.6	29.5	115.1	15.7	74.9	90.6	205.7	8.0	—	213.7
	1975^p	. .	. .	. .	86.0	43.0	129.0	24.7	95.4	120.1	249.1	9.9	. .	. .
Total metal mining[2]	1973	17.9	146.8	189.3	354.0	240.1	594.1	48.0	299.5	347.5	941.6	15.7	0.4	957.7
	1974	20.0	172.2	213.5	405.7	156.6	562.3	58.7	383.3	442.0	1,004.3	18.8	. .	. .
	1975^p	21.6	217.6	256.7	495.9	214.2	710.1	52.8	456.5	509.3	1,219.4	21.7	. .	. .
Nonmetal mining														
Asbestos	1973	0.2	20.9	7.1	28.2	21.5	49.7	2.8	39.8	42.6	92.3	0.1	. .	. .
	1974	0.4	27.4	17.6	45.4	28.9	74.3	2.4	50.7	53.1	127.4	0.2	. .	. .
	1975^p	0.5	28.9	13.0	42.4	19.3	61.7	4.1	46.0	50.1	111.8	0.1	. .	. .
Other non-metal mining	1973	4.0	15.1	20.2	39.3	58.2	97.5	3.7	95.4	99.1	196.6	1.5	. .	. .
	1974	2.1	28.2	40.3	70.6	96.8	167.4	10.7	116.3	127.0	294.4	2.7	5.1	302.2
	1975^p	2.5	27.6	40.0	70.1	190.5	260.6	19.7	137.5	157.2	417.8	7.8	0.2	425.8

Table 49. (concl'd)

		Capital						Repair						
		Construction												
		On-Property Exploration	On-Property Development	Structures	Total	Machinery and Equipment	Total Capital	Construction	Machinery and Equipment	Total Repair	Total Capital and Repair	Outside or General Exploration	Land and Mining Rights	Total all Expenditures
		($ million)												
Total non-metals	1973	4.2	36.0	27.3	67.5	79.7	147.2	6.5	135.2	141.7	288.9	1.6	6.6	297.1
	1974	2.5	55.6	57.9	116.0	125.7	241.7	13.1	167.0	180.1	421.8	2.9	. .	. .
	1975p	3.0	56.5	53.0	112.5	209.8	322.3	23.8	183.5	207.3	529.6	7.9	. .	. .
Metal and non-metal mining exploration	1973	1.1	1.8	0.2	3.1	1.2	4.3	—	0.2	0.2	4.5	69.8	2.1	76.4
	1974	2.7	0.8	0.4	3.9	1.3	5.2	—	0.1	0.1	5.3	89.1	4.9	99.3
	1975p	1.5	0.8	0.1	2.4	2.0	4.4	0.2	0.3	0.5	4.9	99.2	3.2	107.3
Total mining	1973	23.2	184.6	216.8	424.6	321.0	745.6	54.5	434.9	489.4	1,235.0	87.1	9.1	1,331.2
	1974	25.2	228.6	271.8	525.6	283.6	809.2	71.8	550.4	622.2	1,431.4	110.8	20.2	1,562.4
	1975p	26.1	274.9	309.8	610.8	426.0	1,036.8	76.8	640.3	717.1	1,753.9	128.8	11.3	1,894.0

[1] Excludes expenditures in the petroleum and natural gas industries. [2] Confidential figures are included in "Total metal mining."
p Preliminary; — Nil; . . Not available or not applicable.

Table 50. Canada, diamond drilling in the mining industry, by mining companies with own equipment and by drilling contractors, 1972-73

		1972			1973		
		Exploration	Other	Total	Exploration	Other	Total
		(footage)					
Metal mining							
Gold quartz	Own equipment	110,143	60,125	170,268	44,818	29,133	73,951
	Contractors	501,491	82,084	583,575	707,493	18,121	725,614
	Total	611,634	142,209	753,843	752,311	47,254	799,565
Copper-gold-silver	Own equipment	104,312	191,684	295,996	142,425	53,624	196,049
	Contractors	1,281,915	35,801	1,317,716	1,026,979	56,709	1,083,688
	Total	1,386,227	227,485	1,613,712	1,169,404	110,333	1,279,737
Nickel-copper	Own equipment	519,405	427,363	946,768	803,303	23,252	826,555
	Contractors	584,218	29,974	614,192	169,746	63,638	233,384
	Total	1,103,623	457,337	1,560,960	973,049	86,890	1,059,939
Silver-lead-zinc and silver-cobalt	Own equipment	45,354	319,921	365,275	63,694	147,145	210,839
	Contractors	233,737	137,523	371,260	349,829	49,389	399,218
	Total	279,091	457,444	736,535	413,523	196,534	610,057
Molybdenum[1]	Own equipment	—	—	—	. .	. .	. .
	Contractors	3,896	3,896	7,792	. .	. .	. .
	Total	3,896	3,896	7,792	. .	. .	. .
Iron mines	Own equipment	—	—	—	—	—	—
	Contractors	28,255	12,244	40,499	55,288	3,896	59,184
	Total	28,255	12,244	40,499	55,288	3,896	59,184
Miscellaneous metal mining	Own equipment	40,489	—	40,489	—	—	—
	Contractors	76,002	—	76,002	127,999	2,225	130,224
	Total	116,491	—	116,491	127,999	2,225	130,224
Total metal mining	Own equipment	819,703	999,093	1,818,796	1,054,240	253,154	1,307,394
	Contractors	2,709,514	301,522	3,011,036	2,437,334	193,978	2,631,312
	Total	3,529,217	1,300,615	4,829,832	3,491,574	447,132	3,938,706

Table 50. (concl'd)

		1972			1973		
		Exploration	Other	Total	Exploration	Other	Total
		(footage)					
Nonmetal mining							
Asbestos	Own equipment	—	—	—	—	—	—
	Contractors	47,435	17,580	65,015	70,355	—	70,355
	Total	47,435	17,580	65,015	70,355	—	70,355
Feldspar and quartz	Own equipment	—	—	—	—	—	—
	Contractors	6,952	—	6,952	7,144	—	7,144
	Total	6,952	—	6,952	7,144	—	7,144
Gypsum[2]	Own equipment	—	—	—	. .	. .	. .
	Contractors	8,669	—	8,669	. .	. .	. .
	Total	8,669	—	8,669	. .	. .	. .
Salt	Own equipment	4,700	—	4,700	957	—	957
	Contractors	—	—	—	—	—	—
	Total	4,700	—	4,700	957	—	957
Miscellaneous nonmetal mining	Own equipment	5,181	—	5,181	8,396	—	8,396
	Contractors	15,262	—	15,262	12,644	—	12,644
	Total	20,443	—	20,443	21,040	—	21,040
Total nonmetal mining	Own equipment	9,881	—	9,881	9,353	—	9,353
	Contractors	78,318	17,580	95,898	90,143	—	90,143
	Total	88,199	17,580	105,779	99,496	—	99,496
Total mining industry	Own equipment	829,584	999,093	1,828,677	1,063,593	253,154	1,316,747
	Contractors	2,787,832	319,102	3,106,934	2,527,477	193,978	2,721,455
	Total	3,617,416	1,318,195	4,935,611	3,591,070	447,132	4,038,202

[1]1973 data are included in "Miscellaneous metal mining." [2]1973 data are included in "Miscellaneous nonmetal mining."
— Nil; . . Not available or not applicable.

Table 51. Canada, total diamond drilling, metal deposits, 1960-73

	Gold quartz deposits	Copper-gold-silver and nickel-copper deposits	Silver-lead-zinc and silver-cobalt deposits	Other metal-bearing deposits[1]	Total metal deposits
			(footage)		
1960	2,060,419	4,159,424	741,557	1,033,686	7,995,086
1961	1,952,693	3,701,085	836,945	725,325	7,216,048
1962	2,960,265	3,363,019	1,148,886	1,176,768	8,648,938
1963	1,738,710	3,206,225	945,553	487,872	6,378,360
1964	1,505,686	2,328,045	1,315,944	343,631	5,493,306
1965	1,443,637	2,557,535	1,086,923	905,241	5,993,336
1966	1,451,598	2,392,220	958,737	538,891	5,341,446
1967	1,283,947	3,110,090	755,193	394,851	5,544,081
1968	1,231,179	3,069,935	649,731	186,288	5,137,133
1969	900,297	3,029,700	648,525	359,557	4,938,079
1970	704,455	3,716,915	1,230,380	326,027	5,977,777
1971	634,158	3,573,174	1,013,119	275,103	5,495,554
1972	753,843	3,174,672	736,535	164,782	4,829,832
1973	799,565	2,339,676	610,057	189,408	3,938,706

Note: Non-producing companies not included since 1964.
[1]Includes iron, titanium, uranium, molybdenum and other metal deposits.

Table 52. Canada, exploration diamond drilling, metal deposits, 1960-73

	Mining companies with own personnel and equipment	Diamond drill contractors	Total
		(footage)	
1960	880,515	4,624,067	5,504,582
1961	993,099	4,387,051	5,380,150
1962	548,603	5,734,983	6,283,586
1963	1,184,977	3,836,262	5,021,239
1964	469,205	3,520,293	3,989,498
1965	685,704	3,861,537	4,547,241
1966	536,022	3,428,021	3,964,043
1967	305,657	3,684,833	3,990,490
1968	522,775	3,250,298	3,773,073
1969	443,936	3,518,138	3,962,074
1970	203,896	4,029,074	4,232,970
1971	284,902	3,455,810	3,740,712
1972	819,703	2,709,514	3,529,217
1973	1,054,240	2,437,334	3,491,574

Note: Non-producing companies are not included since 1964. See footnote to Table 53.

Table 53. Canada, diamond drilling other than for exploration, metal deposits, 1960-73

	Mining companies with own personnel and equipment	Diamond drill contractors	Total
		(footage)	
1960	1,477,185	1,013,319	2,490,504
1961	1,261,262	574,636	1,835,898
1962	1,734,581	630,771	2,365,352
1963	1,273,714	83,407	1,357,121
1964	1,265,636	238,172	1,503,808
1965	1,292,479	153,616	1,446,096
1966	747,929	629,474	1,377,403
1967	611,755	941,836	1,553,591
1968	403,056	961,004	1,364,060
1969	287,247	688,758	976,005
1970	952,637	792,170	1,744,807
1971	971,018	783,924	1,754,842
1972	999,093	301,522	1,300,615
1973	253,154	193,978	447,132

Note: Non-producing companies not included since 1964.The total footage drilled shown in Tables 52 and 53 equals the total footage reported in Table 51.

Table 54. Canada, total contract diamond drilling operations,[1] 1961-73

	Footage drilled	Income from drilling	Average number of employees	Total Salaries and wages
		($ million)		($ million)
1961	5,290,813	16.2	2,025	7.8
1962	5,549,733	17.9	1,926	8.0
1963	5,702,168	20.1	2,201	9.0
1964	6,479,096	23.7	2,401	11.2
1965	7,404,834	30.7	2,776	14.1
1966	7,466,264	33.7	2,887	15.1
1967	6,957,269	31.3	2,669	14.9
1968	7,615,175	38.7	2,985	18.8
1969	7,766,957	44.8	3,109	21.3
1970	7,627,493	53.2	3,207	24.3
1971	6,195,715	38.1	2,514	18.9
1972	5,177,882	35.9	2,083	16.6
1973	5,239,396	39.1	2,123	18.7

[1]Includes contract diamond drilling in mining and in other industries.

Table 55. Canada, contract drilling for oil and natural gas, 1962-73

	Footage drilled				Gross income from drilling	Number of employees	Total salaries and wages
	Rotary	Cable	Diamond	Total	($ million)		($ million)
1962	12,459,736	252,467	—	12,712,203	62.2	3,800	20.8
1963	13,783,110	361,979	—	15,145,089	75.9	4,179	22.9
1964	14,803,776	229,726	6,230	15,039,732	81.9	4,158	25.2
1965	15,997,276	340,345	—	16,337,621	100.2	4,648	31.7
1966	13,394,413	210,104	—	13,604,517	95.8	4,428	33.9
1967	12,717,419	168,035	—	12,885,454	94.7	4,249	32.9
1968	13,300,766	230,443	—	13,531,209	109.5	4,434	36.9
1969	13,038,137	280,323	—	13,318,460	115.5	4,821	39.5
1970	11,500,845	165,042	—	11,665,887	112.6	4,267	37.9
1971	11,650,353	134,522	—	11,784,875	109.5	4,093	38.0
1972	14,213,386	138,983	—	14,352,369	154.6	4,817	53.5
1973	16,015,530	78,890	—	16,094,420	213.3	5,680	75.5

— Nil.

Table 56. Canada, crude minerals transported by Canadian railways, 1973-74

	1973	1974
	(thousand short tons)	
Metallic minerals		
Alumina and bauxite	2,606	3,055
Copper ores and concentrates	2,910	3,045
Iron ores and concentrates	57,728	56,016
Iron pyrite	23	45
Lead ores and concentrates	798	684
Lead-zinc ores and concentrates	97	75
Manganese ores	29	40
Nickel-copper ores and concentrates	2,670	3,816
Nickel ores and concentrates	1,338	1,725
Zinc ores and concentrates	2,606	2,468
Metallic ores and concentrates, nes	146	147
Total metallic minerals	70,951	71,116
Nonmetallic minerals		
Abrasives, natural	106	140
Asbestos	1,194	1,225
Barite	86	73
Clay	742	710
Gravel	3,269	1,392
Gypsum	5,101	4,446
Limestone, agricultural	205	166
Limestone, industrial	413	511
Limestone, nes	4,332	4,460
Nepheline syenite	351	13
Phosphate rock	2,170	2,671
Potash (KCl)	7,989	10,010
Refractory materials, nes	22	23
Salt, rock	1,133	1,099
Salt, nes	272	289
Sand, industrial	1,757	1,719
Sand, nes	1,354	1,008
Silica	9	40
Sodium carbonate	639	596
Sodium sulphate	614	779
Stone, building, rough	89	135
Stone, nes	1,192	1,748
Sulphur, liquid	1,425	1,823
Sulphur, nes	3,164	3,757
Nonmetallic minerals, nes	595	415
Total nonmetallic minerals	38,223	39,248
Mineral fuels		
Coal, anthracite	391	372
Coal, bituminous	14,035	15,524
Coal, lignite	737	430
Coal, nes	27	39
Natural gas and other crude bituminous substances	7	8
Petroleum, crude	318	382
Total mineral fuels	15,515	16,755
Total crude minerals	124,689	127,119
Total revenue freight moved by Canadian railways	265,946	271,576
Per cent crude minerals of total revenue freight	46.9	46.8

nes Not elsewhere specified.

Table 57. Canada, crude minerals transported by Canadian railways, 1965-74

Year	Total Revenue Freight	Total Crude Minerals	Crude Minerals as % of Total Revenue Freight
	(million short tons)		
1965	205.2	89.2	43.5
1966	214.4	88.9	41.5
1967	209.5	89.5	42.7
1968	215.4	95.6	44.4
1969	208.3	90.3	43.4
1970	233.3	107.5	46.1
1971	236.4	105.4	44.6
1972	237.9	98.6	41.4
1973	265.9	124.7	46.9
1974	271.5	127.1	46.8

Table 58. Canada, fabricated mineral products transported by Canadian railways, 1973-74

	1973	1974
	(thousand short tons)	
Metallic mineral products		
Ferrous mineral products		
Ferroalloys	191	230
Pig iron	209	221
Ingots, blooms, billets, slabs of iron and steel	692	609
Other primary iron and steel	52	119
Castings and forgings, iron and steel	315	327
Bars and rods, steel	969	1,275
Plates, steel	498	673
Sheet and strip, steel	1,738	1,815
Structural shapes and sheet piling, iron and steel	575	702
Rails and railway track material	243	240
Pipes and tubes, iron and steel	725	771
Wire, iron or steel	50	67
Iron and steel scrap	2,007	2,360
Slag, dross, etc.	260	277
Total ferrous mineral products	8,524	9,686
Nonferrous mineral products		
Aluminum paste, powder, pigs, ingots, shot	183	173
Aluminum and aluminum alloy fabricated material, nes	321	306
Copper matte and precipitates	5	2
Copper and alloys, in primary forms	464	580
Copper and alloys, nes	78	172
Lead and alloys	196	141
Nickel and nickel-copper matte	177	173
Nickel and alloys	86	91
Zinc and alloys	558	464
Other nonferrous base metals and alloys	17	22
Nonferrous metal scrap	185	237
Total nonferrous mineral products	2,270	2,361
Total metallic mineral products	10,794	12,047
Nonmetallic mineral products		
Natural stone basic products, chiefly structural	206	299
Bricks and tiles, clay	99	113
Fire brick and similar shapes	208	262
Dolomite and magnesite, calcined	83	69
Refractories, nes	75	70
Glass basic products	162	241
Asbestos and asbestos-cement basic products	20	21
Portland cement, standard	1,814	1,970
Concrete pipe	91	99
Cement and concrete basic products, nes	236	325
Plaster	66	56
Gypsum wallboard and sheathing	98	117
Gypsum basic products, nes	2	2
Lime, hydrated and quick	726	702
Nonmetallic mineral basic products, nes	591	698
Fertilizers and fertilizer materials nes	2,470	2,160
Total nonmetallic mineral products	6,947	7,204
Mineral fuel products		
Gasoline	2,255	2,233
Aviation turbine fuel	91	118
Diesel fuel	3,937	4,108
Kerosene	13	19
Fuel oil, nes	968	1,005
Lubricating oils and greases	454	492
Petroleum coke	306	430
Coke, nes	1,413	1,536
Refined and manufactured gases, fuel type	3,946	3,714
Asphalts and road oils	369	326
Bituminous pressed or molded fabricated materials	2	3
Other petroleum and coal products	549	861
Total mineral fuel products	14,303	14,845
Total fabricated mineral products	32,044	43,782
Total revenue freight moved by Canadian railways	265,946	271,516
Fabricated mineral products as a percentage of total revenue freight	12.0	16.1

nes Not elsewhere specified.

Table 59. Canada, crude and fabricated minerals transported through the St. Lawrence Seaway, 1974-75

	Montreal-Lake Ontario Section		Welland Canal Section	
	1974	1975	1974	1975
	(short tons)			
Crude minerals				
Bituminous coal	193,116	439,354	6,483,941	8,488,700
Iron ore	14,291,462	14,505,669	14,913,659	16,468,942
Aluminum ores and concentrates	16,570	29,094	16,570	29,094
Clay and bentonite	272,950	173,948	290,850	190,537
Gravel and sand	430	13,987	127,321	296,713
Stone, ground or crushed	44,734	72,834	1,435,326	1,177,593
Stone, rough	5,674	4,380	5,594	4,341
Petroleum, crude	1,237,867	189,200	178,031	—
Salt	894,927	859,315	1,549,689	1,494,853
Phosphate rock	—	69,163	—	—
Sulphur	84,571	34,807	84,571	34,807
Other crude minerals	745,864	911,993	1,317,492	585,180
Total crude minerals	17,788,165	17,303,744	26,403,044	28,770,760
Fabricated mineral products				
Coke	1,312,341	918,044	490,555	884,973
Gasoline	125,864	222,914	168,605	170,945
Fuel oil	1,999,308	1,951,112	1,178,544	1,138,195
Lubricating oils and greases	196,421	154,369	189,857	139,422
Other petroleum products	144,629	132,948	103,302	86,616
Tar, pitch and creosote	43,918	35,479	77,598	64,311
Pig iron	135,223	136,290	130,863	123,040
Iron and steel: bars, rods, slabs	545,736	600,322	517,583	559,537
Iron and steel: nails, wire	67,682	27,618	59,875	25,905
Iron and steel: other manufactured products	2,991,938	1,837,147	2,707,994	1,633,447
Scrap iron and steel	136,749	660,582	124,487	616,716
Cement	36,278	15,378	244,354	211,055
Total fabricated minerals	7,736,087	6,692,203	5,993,617	5,654,162
Total crude and fabricated minerals	25,524,252	23,995,947	32,396,661	34,424,922
Total, all products	44,146,444	48,010,403	52,359,962	58,849,026
Per cent crude and fabricated minerals of total, all products	57.8	50.0	61.9	58.5

— Nil.

Table 60. Canada, crude minerals loaded and unloaded in coastwise shipping, 1974

	Loaded				Unloaded			
	Atlantic	Great Lakes	Pacific	Total	Atlantic	Great Lakes	Pacific	Total
	(short tons)							
Metallic minerals								
Copper ore and concentrates	39,227	–	1,375	40,602	39,227	–	1,375	40,602
Iron ore and concentrates	4,079,638	3,138,180	–	7,217,818	1,048,234	6,169,584	–	7,217,818
Manganese ore	98,671	–	–	98,671	86,239	12,432	–	98,671
Titanium ore	2,288,078	–	–	2,288,078	2,288,078	–	–	2,288,078
Zinc ore and concentrates	4,540	17,731	–	22,271	22,271	–	–	22,271
Ores and concentrates, nes	2,739	–	300	3,039	161	2,578	300	3,039
Iron and steel scrap	30,724	–	3,880	34,604	30,724	–	3,880	34,604
Nonferrous metal scrap	32	–	–	32	32	–	–	32
Slag, dross, residue	2,128	4,000	–	6,128	2,128	4,000	–	6,128
Total metals	6,545,777	3,159,911	5,555	9,711,243	3,517,094	6,188,594	5,555	9,711,243
Nonmetallic minerals								
Asbestos	–	–	–	–	–	–	–	–
Barite	150	–	–	150	150	–	–	150
Clays, nes	866	–	–	866	866	–	–	866
Dolomite	–	21,691	–	21,691	21,691	–	–	21,691
Fluorspar	214,019	–	–	214,019	182,988	31,031	–	214,019
Gypsum	635,557	–	–	635,557	525,147	110,410	–	635,557
Limestone	9,708	2,717,443	355,136	3,082,287	9,708	2,717,443	355,136	3,082,287
Potash (KCl)	–	–	–	–	–	–	–	–
Salt	250,024	1,406,540	44,413	1,700,977	947,132	709,432	44,413	1,700,977
Sand and gravel	1,329	4,000	2,894,779	2,900,108	1,329	4,000	2,894,779	2,900,108
Stone, crushed	288	–	–	288	288	–	–	288
Stone, crude, nes	213	282,093	3,924	286,230	213	282,093	3,924	286,230
Sulphur	–	–	16,014	16,014	–	–	16,014	16,014
Crude nonmetallic minerals, nes	75	–	1,596	1,671	75	–	1,596	1,671
Total nonmetals	1,112,229	4,431,767	3,315,862	8,859,858	1,689,587	3,854,409	3,315,862	8,859,858
Mineral fuels								
Coal, bituminous	3,295	347,780	402	351,477	3,895	347,180	402	351,477
Total crude minerals	7,661,301	7,939,458	3,321,819	18,922,578	5,210,576	10,390,183	3,321,819	18,922,578
Total, all commodities	21,753,232	23,748,727	13,618,678	59,120,637	28,206,052	18,295,671	12,618,914	59,120,637
Per cent crude minerals, total of all commodities	35.2	33.4	24.4	32.0	18.5	56.8	26.3	32.0

– Nil; nes Not elsewhere specified.

Table 61. Canada, crude minerals loaded and unloaded at Canadian ports in international shipping trade, 1973-74

	1973		1974	
	Loaded	Unloaded	Loaded	Unloaded
	(short tons)			
Metallic minerals				
Alumina, bauxite ore	31,300	3,466,017	–	3,893,284
Copper ores and concentrates	1,168,100	88,783	1,070,804	68,529
Iron ore and concentrates	39,696,664	3,039,921	40,686,846	3,417,113
Lead ore and concentrates	94,546	–	152,372	–
Manganese ore	47,713	326,924	39,644	317,720
Nickel-copper ore and concentrates	124,433	15,454	94,490	5,921
Titanium ore	694,638	16,437	750,142	2,688
Zinc ore and concentrates	1,334,028	–	1,313,878	–
Ores and concentrates, nes	78,829	99,815	56,100	82,219
Iron and steel scrap	358,135	3,013	43,274	2,178
Nonferrous metal scrap	21,217	335	2,694	560
Slag, dross, residue	770,796	37,264	781,918	38,888
Total metals	44,420,399	7,093,963	44,992,162	7,829,100
Nonmetallic minerals				
Asbestos	518,162	1,963	583,299	3,523
Barite	49,862	3,320	34,297	–
Bentonite	16	192,081	20	202,041
China clay	–	33,413	–	33,476
Clays, nes	31,949	78,457	913	50,729
Dolomite	1,358,104	–	1,400,688	–
Fluorspar	58,650	240,523	31,016	210,676
Gypsum	6,303,738	79,223	5,713,725	64,100
Limestone	1,367,710	2,313,699	970,096	2,932,662
Phosphate rock	35,750	1,423,381	–	1,459,984
Potash (KCl)	1,486,484	10,432	1,942,519	–
Salt	1,109,699	878,150	1,116,736	907,679
Sand and gravel	81,665	1,258,855	99,400	1,407,885
Stone, crushed	16	72,454	–	–
Stone, crude, nes	90,402	12,412	79,264	18,968
Sulphur	2,297,967	34,792	2,460,163	23,617
Crude nonmetallic minerals, nes	25,499	29,265	101,926	13,059
Total nonmetals	14,815,673	6,662,420	14,534,062	7,328,399
Mineral fuels				
Coal, bituminous	10,467,592	15,749,593	9,368,300	13,200,257
Coal, nes	3	408,426	–	324,906
Natural gas	65	–	–	–
Petroleum, crude	1,059,236	22,386,173	1,756,086	21,156,767
Total fuels	11,526,896	38,544,192	11,124,386	34,681,930
Total crude minerals	70,762,968	52,300,575	70,650,610	49,839,429
Total, all commodities	123,937,304	72,708,223	116,966,358	66,930,216
Per cent crude minerals of total, all commodities	57.1	71.9	60.4	74.5

– Nil; nes Not elsewhere specified.

Table 62. Canada, fabricated mineral products loaded and unloaded at Canadian ports in international shipping trade, 1973-74

	1973		1974	
	Loaded	Unloaded	Loaded	Unloaded
	(short tons)			
Metallic products				
Aluminum	369,367	17,993	318,627	3,961
Copper and alloys	47,344	2,000	47,461	8,526
Ferroalloys	13,354	61,404	12,205	74,915
Iron and steel, primary	26,216	36,090	187,147	67,462
Iron, pig	553,307	77	449,880	—
Iron and steel, other bars and rods	40,095	175,444	21,570	269,456
castings and forgings	9,153	29,401	3,687	14,424
pipe and tubes	24,043	57,671	38,725	83,646
plate and sheet	186,309	439,352	153,457	753,925
rails and track material	19,937	8,545	40,509	43,417
structural shapes	58,516	362,144	54,590	590,873
wire	5,642	12,469	4,167	35,718
Lead and alloys	19,442	56	13,275	4,650
Nickel and alloys	23,036	22,873	16,911	15,537
Zinc and alloys	58,764	5,451	35,172	805
Nonferrous metals, nes	32,448	19,051	28,474	10,314
Metal fabricated basic products	29,905	70,868	16,007	42,717
Total metals	1,516,878	1,320,889	1,441,864	2,020,346
Nonmetallic products				
Asbestos basic products	4,758	2,706	6,496	2,457
Building brick, clay	296	2,563	90	1,787
Bricks and tiles, nes	11,596	6,415	13,475	16,802
Cement	1,717,128	60,815	1,322,749	119,009
Cement basic products	1,379	2,882	224	603
Drain tiles and pipes	—	239	214	119
Glass basic products	11,431	28,174	10,980	23,465
Lime	5,558	1,830	3,498	141
Nonmetallic mineral basic products	5,929	10,686	2,851	5,816
Fertilizers, nes	147,790	69,073	277,127	83,705
Total nonmetals	1,905,865	185,383	1,637,704	253,904
Mineral fuel products				
Asphalts, road oils	2,255	7,948	41,443	194
Coal tar, pitch	9,971	66,661	7,064	71,488
Coke	375,111	841,480	343,638	906,620
Fuel oil	6,295,604	5,374,500	5,598,431	3,509,343
Gasoline	410,456	13,450	145,386	5,493
Lubricating oils and greases	1,554	32,210	1,907	59,138
Petroleum and coal products, nes	618,526	149,644	748,913	43,396
Total fuels	7,713,477	6,485,893	6,886,782	4,595,672
Total fabricated mineral products	11,136,220	7,992,165	9,966,350	6,869,922
Total, all commodities	123,937,304	72,708,223	116,966,358	66,930,216
Per cent fabricated mineral products of total, all commodities	9.0	11.0	8.5	10.3

— Nil; nes Not elsewhere specified.

Table 63. Canada, financial statistics of corporations in the mining industry,[1]

	Corporations		Assets	
	(number)	(%)	($ million)	(%)
Metal mines				
Reporting corporations				
50 per cent and over non-resident	49	23.0	3,162	33.8
Under 50 per cent non-resident	115	54.0	6,079	65.0
Government business enterprise	2	1.0	. .	. .
Other corporations	47	22.0	. .	. .
Total, all corporations	213	100.0	9,346	100.0
Mineral fuels				
Reporting corporations				
50 per cent and over non-resident	255	29.5	6,023	77.1
Under 50 per cent non-resident	260	30.1	1,699	21.7
Government business enterprise	3	0.4	75	1.0
Other corporations	347	40.0	19	0.2
Total, all corporations	865	100.0	7,816	100.0
Other mining (including mining services)				
Reporting corporations				
50 per cent and over non-resident	218	7.7	1,902	56.9
Under 50 per cent non-resident	993	34.9	1,282	38.4
Government business enterprise	3	0.1	. .	. .
Other corporations	1,632	57.3	. .	. .
Total, all corporations	2,846	100.0	3,341	100.0
Total mining				
Reporting corporations				
50 per cent and over non-resident	522	13.3	11,087	54.1
Under 50 per cent non-resident	1,368	34.9	9,061	44.2
Government business enterprise	8	0.2	204	1.0
Other corporations	2,026	51.6	151	0.7
Total, all corporations	3,924	100.0	20,503	100.0

Note: Footnotes for Table 64 apply to this table.
[1]Classification of the industry is the same as in Table 27.
. . Not available or not applicable; — Nil; — — Amount too small to be expressed.

by degree of non-resident ownership, 1973

Equity		Sales		Profits		Taxable income	
($ million)	(%)	($ million)	(%)	($ million)	(%)	($ million)	(%)
1,338	27.1	1,295	30.0	304	23.7	56.9	20.2
3,554	72.0	3,000	69.5	980	76.5	224.8	79.8
. .	. .	. .	. .	. .	. .	—	—
. .	. .	. .	. .	. .	. .	—	—
4,936	100.0	4,315	100.0	1,281	100.0	281.7	100.0
3,940	77.4	2,920	89.6	536	86.2	228.5	93.5
1,089	21.4	305	9.4	92	14.8	15.0	6.1
64	1.2	26	0.8	−4	−0.6	—	—
— —	— —	10	0.2	−2	−0.4	0.9	0.4
5,092	100.0	3,260	100.0	622	100.0	244.4	100.0
1,035	54.4	934	62.4	158	86.3	48.2	67.0
790	41.5	480	32.1	24	13.1	18.3	25.5
. .	. .	. .	. .	. .	. .	—	—
. .	. .	. .	. .	. .	. .	5.4	7.5
1,903	100.0	1,497	100.0	183	100.0	71.9	100.0
6,313	52.9	5,149	56.8	998	47.8	333.5	55.8
5,433	45.5	3,785	41.7	1,096	52.5	258.1	43.2
132	1.1	49	0.5	−6	−0.3	—	—
53	0.5	89	1.0	−2	—	6.4	1.0
11,931	100.0	9,072	100.0	2,087	100.0	598.0	100.0

Table 64. Canada, financial statistics of corporations in the mineral manufacturing

	Corporations[2]		Assets[5]	
	(number)	(%)	($ million)	(%)
Primary metal products				
Reporting corporations[2]				
50% and over non-resident	57	12.7	2,022	38.9
under 50% non-resident	168	37.7	2,903	55.8
Government business enterprises[3]	4	1.0	254	4.9
Other[4]	217	48.6	20	0.4
Total, all corporations	446	100.0	5,199	100.0
Nonmetallic mineral products				
Reporting corporations[2]				
50% and over non-resident	97	9.1	1,493	62.3
under 50% non-resident	459	43.1	850	35.5
Government business enterprises[3]	2	0.2	. .	. .
Others[4]	506	47.6	. .	. .
Total, all corporations	1,064	100.0	2,398	100.0
Petroleum and coal products				
Reporting corporations[2]				
50% and over non-resident	21	40.4	7,471	97.2
under 50% non-resident	18	34.6	216	2.8
Government business enterprises[3]	—	—	—	—
Other[4]	13	25.0	1	— —
Total, all corporations	52	100.0	7,689	100.0
Total mineral manufacturing industries				
Reporting companies[2]				
50% and over non-resident	175	11.2	10,986	70.7
under 50% non-resident	645	41.3	3,969	25.5
Government business enterprises[3]	6	0.4	. .	. .
Other[4]	736	47.1	. .	. .
Total, all corporations	1,562	100.0	15,540	100.0

[1]Classification of industries is the same as in Table 28. [2]Corporations reporting under the Corporations and Labour Unions Returns Act. A corporation is considered to be foreign controlled if 50% or more of its voting rights are known to be held outside Canada, and/or by one or more Canadian corporations which are, in turn, foreign controlled. Each corporation is classified according to the percentage of its voting rights which are owned by non-residents, either directly or through other Canadian corporations, and the whole of the corporation is assigned to this particular degree of foreign ownership. [3]Non-taxable federal and provincial Crown Corporations and municipally-owned corporations. [4]Corporations exempt from reporting under the Corporations and Labour Unions Returns Act. These include corporations reporting under other acts, small companies and corporations and non-profit organizations. [5]Included are cash, marketable securities, accounts receivable, inventories, fixed assets, investments in affiliated corporations and other assets. The amounts tabulated are those shown on the balance sheets of corporations after deducting allowances for doubtful accounts, amortization, depletion and depreciation. [6]Equity represents the shareholders' interest in the net assets of the corporation and includes the total amount of all issued and paid-up share capital, earnings retained in the business and other surplus accounts such as contributed and capital surplus. [7]For non-financial corporations, sales are gross revenues from non-financial operations. For financial corporations sales include income from financial as well as non-financial sources. [8]The net earnings from operations, investment income and net capital gains. Profits are tabulated after deducting allowances for amortization, depletion and depreciation, but before income tax provisions or declaration of dividends. [9]Taxable income figures are as reported by corporations prior to assessment by the Department of National Revenue. They include earnings in the reference year after the deduction of applicable losses of other years.

— Nil; . . Not available or not applicable; — — Amount too small to be expressed.

industries,[1] by degree of non-resident ownership, 1973

Equity[6]		Sales[7]		Profits[8]		Taxable income[9]	
($ million)	(%)	($ million)	(%)	($ million)	(%)	($ million)	(%)
973	38.1	1,567	36.1	91	22.3	39.8	19.5
1,518	59.5	2,541	58.6	328	80.2	162.5	79.7
55	2.2	196	4.5	−25	−5.9	—	—
5	0.2	35	0.8	14	3.4	1.7	0.8
2,551	100.0	4,340	100.0	409	100.0	204.0	100.0
868	72.9	1,061	50.2	149	69.6	76.2	72.0
297	25.0	982	46.5	62	29.0	26.5	25.1
. .	. .	. .	. .	. .	. .	—	—
. .	. .	. .	. .	. .	. .	3.1	2.9
1,190	100.0	2,113	100.0	214	100.0	105.8	100.0
4,540	97.7	6,489	97.6	929	96.8	403.4	99.6
106	2.3	158	2.4	31	3.2	1.5	0.4
—	—	—	—	—	—	—	—
1	——	2	——	—	—	0.2	——
4,646	100.0	6,649	100.0	960	100.0	405.1	100.0
6,381	76.1	9,117	69.6	1,169	73.9	519.4	72.7
1,921	22.9	3,681	28.1	421	26.6	190.5	26.7
. .	. .	. .	. .	. .	. .	—	—
. .	. .	. .	. .	. .	. .	5.0	0.6
8,387	100.0	13,102	100.0	1,583	100.0	714.9	100.0

Table 65. Canada, financial statistics of corporations in non-financial industries,

		Agriculture, Forestry, Fishing and Trapping		Mining		Manufacturing	
		1972	1973p	1972	1973p	1972	1973p
Number of corporations							
Foreign control	number	99	111	504	522	2,325	2,336
Canadian control	number	2,127	2,639	1,243	1,368	8,135	8,928
Other corporations	number	5,399	5,763	1,974	2,034	12,561	12,954
Total corporations	number	7,625	8,513	3,721	3,924	23,021	24,218
Assets							
Foreign control	$ million	200	239	11,745	11,087	29,902	34,324
Canadian control	$ million	1,130	1,423	6,117	9,061	21,970	24,161
Other corporations	$ million	. .	563	354	355	1,474	1,672
Total corporations	$ million	1,860	2,225	18,216	20,503	53,346	60,157
Equity							
Foreign control	$ million	99	111	6,745	6,313	15,724	17,761
Canadian control	$ million	366	496	3,705	5,433	9,655	10,338
Other corporations	$ million	. .	136	178	185	421	406
Total corporations	$ million	582	743	10,628	11,931	25,800	28,505
Sales							
Foreign control	$ million	130	182	4,381	5,149	36,722	43,453
Canadian control	$ million	912	1,302	1,819	3,785	26,635	31,577
Other corporations	$ million	. .	491	126	138	2,064	2,048
Total corporations	$ million	1,472	1,975	6,326	9,072	65,421	77,079
Profits							
Foreign control	$ million	7	16	586	998	2,832	3,971
Canadian control	$ million	60	155	230	1,096	1,510	2,633
Other corporations	$ million	. .	38	−19	−8	19	66
Total corporations	$ million	81	209	797	2,087	4,361	6,670
Taxable income[1]							
Foreign control	$ million	4.6	. .	114.4	. .	2,167.5	. .
Canadian control	$ million	26.2	. .	69.9	. .	995.2	. .
Other corporations	$ million	11.7	. .	−1.4	. .	49.6	. .
Total corporations	$ million	42.8	. .	182.9	. .	3,212.3	. .

Note: Figures may not add to total due to rounding.
[1] 1973 taxable income data not available.
p Preliminary; . . Not available or not applicable.

by major industry group and by control, 1972 and 1973

Construction		Transportation, communication and other utilities		Trade		Services		Total	
1972	1973^{p}	1972	1973^{p}	1972	1973^{p}	1972	1973^{p}	1972	1973^{p}
173	192	253	271	1,823	1,864	546	569	5,723	5,865
5,655	6,798	2,158	2,522	16,703	19,048	5,360	6,556	41,381	47,859
17,170	19,096	7,420	7,963	44,212	47,048	28,638	31,415	117,374	126,273
22,998	26,086	9,831	10,756	62,738	67,960	34,544	38,540	164,478	179,997
1,073	1,120	2,858	3,099	6,967	7,874	1,845	2,302	54,590	60,045
5,909	6,916	16,954	18,720	14,824	17,278	5,067	5,993	71,971	83,552
1,169	1,239	27,353	29,863	4,149	4,495	. .	1,961	. .	40,148
8,151	9,275	47,165	51,682	25,940	29,647	8,716	10,256	163,394	183,745
275	294	1,042	1,198	2,863	3,038	622	737	27,370	29,452
1,263	1,446	6,893	7,317	5,431	5,950	1,832	2,036	29,145	33,016
363	381	6,871	7,244	1,213	1,272	. .	603	. .	10,227
1,901	2,121	14,806	15,759	9,507	10,260	3,012	3,377	66,236	72,696
1,396	1,417	1,069	1,317	13,533	15,941	1,372	1,518	58,603	68,977
7,571	9,036	7,113	8,028	36,965	43,273	3,922	4,626	84,937	101,627
2,261	2,397	6,139	6,827	8,760	9,163	. .	2,594	. .	23,658
11,228	12,850	14,321	16,172	59,259	68,377	7,705	8,738	165,732	194,263
85	91	155	201	632	633	131	156	4,428	6,066
264	362	1,032	1,163	1,101	1,433	218	288	4,415	7,130
47	102	296	329	668	925	. .	174	. .	1,626
396	555	1,483	1,693	2,401	2,991	460	618	9,979	14,823
55.3	. .	133.2	. .	477.9	. .	106.4	. .	3,059.6	. .
199.1	. .	440.4	. .	929.6	. .	137.2	. .	2,797.6	. .
80.9	. .	27.1	. .	203.0	. .	95.2	. .	466.1	. .
335.3	. .	600.7	. .	1,610.5	. .	238.8	. .	6,323.3	. .

Table 66. Canada, capital and repair expenditures in mining[1] and mineral manufacturing industries, 1974, 1975, and 1976

	1974			1975^p			1976^f		
	Capital	Repair	Total	Capital	Repair	Total	Capital	Repair	Total
	($ million)								
Mining industry									
Metal mines									
Gold	30.4	9.7	40.1	29.6	12.7	42.3	24.3	13.9	38.2
Silver-lead-zinc	52.7	24.9	77.6	81.8	30.9	112.7	86.3	34.5	120.8
Copper-gold-silver	164.4	123.4	287.8	165.9	107.9	273.8	203.0	104.3	307.3
Iron	199.7	193.4	393.1	290.8	194.8	485.6	439.1	205.7	644.8
Other metal mines	120.3	90.7	211.0	132.8	109.9	242.7	207.5	132.0	339.5
Total metal mines	567.5	442.1	1,009.6	700.9	456.2	1,157.1	960.2	490.4	1,450.6
Nonmetal mines									
Asbestos	74.3	53.1	127.4	64.1	49.2	113.3	94.0	68.7	162.7
Other nonmetal mines[2]	167.4	127.0	294.4	234.7	131.1	365.8	251.1	151.1	402.2
Total nonmetals mines	241.7	180.1	421.8	298.8	180.3	479.1	345.1	219.8	564.9
Mineral fuels									
Petroleum and gas[3]	1,226.2	221.3	1,447.5	1,622.5	239.6	1,862.1	2,148.1	282.5	2,430.6
Total mining industries	2,035.4	843.5	2,878.9	2,622.2	876.1	3,498.3	3,453.4	992.7	4,446.1
Mineral manufacturing									
Primary metal industries									
Iron and steel mills	409.7	302.1	711.8	546.4	366.6	913.0	537.7	417.1	954.8
Steel pipe and tube mills	21.2	22.4	43.6	28.4	24.2	52.6	9.1	27.7	36.8
Iron foundries	22.8	17.0	39.8	28.0	19.5	47.5	25.3	18.7	44.0
Smelting and refining	191.3	197.7	389.0	160.8	209.9	370.7	164.0	204.5	368.5
Aluminum rolling, casting and extruding	14.5	6.2	20.7	4.8	5.0	9.8	5.5	5.4	10.9
Other primary metal industries	38.2	13.5	51.7	37.5	13.9	51.4	26.1	17.2	43.3
Total primary metal industries	697.7	558.9	1,256.6	805.9	639.1	1,445.0	767.7	690.6	1,458.3

Table 66. (concl'd)

	1974			1975[p]			1976[f]		
	Capital	Repair	Total	Capital	Repair	Total	Capital	Repair	Total
					($ million)				
Nonmetallic mineral products									
Cement	44.1	29.0	73.1	68.8	32.6	101.4	80.4	37.7	118.1
Lime[4]	. .	. .	. .	. .	. .	. .	. .	. .	. .
Gypsum products[4]	. .	. .	. .	. .	. .	. .	. .	. .	. .
Concrete products and ready-mix	72.5	67.8	140.3	53.3	66.1	119.4	44.1	63.7	107.8
Clay products	8.3	5.8	14.1	16.9	4.4	21.3	6.6	5.2	11.8
Refractories[4]	. .	. .	. .	. .	. .	. .	. .	. .	. .
Asbestos[4]	. .	. .	. .	. .	. .	. .	. .	. .	. .
Glass and glass products[5]	12.5	9.0	21.5	15.7	8.2	23.9	. .	. .	. .
Abrasives	5.7	9.4	15.1	9.1	8.4	17.5	11.2	9.0	20.2
Other nonmetallic mineral products	31.1	21.2	52.3	29.5	22.9	52.4	94.3	36.3	130.6
Total nonmetallic mineral products	174.2	142.2	316.4	193.3	142.6	335.9	236.6	151.9	388.5
Petroleum and coal products	429.5	110.8	540.3	455.9	126.7	582.6	439.5	139.7	579.2
Total mineral manufacturing industries	1,301.4	811.9	2,113.3	1,455.1	908.4	2,363.5	1,443.8	982.2	2,426.0
Total mining and mineral manufacturing industries	3,336.8	1,655.4	4,992.2	4,077.3	1,784.5	5,861.8	4,897.2	1,974.9	6,872.1

[1]Does not include cement, lime and clay products (domestic clay) manufacturing, smelting and refining. [2]Includes coal mines, gypsum, salt, potash and miscellaneous nonmetal mines and quarrying. [3]The total of capital expenditures shown under "petroleum and gas" is equal to the total capital expenditure under the column entitled "petroleum and natural gas extraction" and under the column "natural gas processing plants" of Table 69. [4]Shown separately during past years, but included in other nonmetallic mineral products for 1974-76. [5]1976 data are included with other nonmetallic mineral products.
[p]Preliminary; [f]Forecast; . . Not available or not applicable.

Table 67. Canada, capital and repair expenditures in the mining industry,[1] 1966-76

	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975^p	1976^f
						($ million)					
Metal mines											
Capital											
Construction	209.9	238.1	264.8	295.1	335.6	590.8	345.7	357.1	409.6	478.4	659.2
Machinery	138.5	131.3	105.2	98.2	150.3	239.8	313.0	241.3	157.9	222.5	301.0
Total	348.4	369.4	370.0	393.3	485.9	830.6	658.7	598.4	567.5	700.9	960.2
Repair											
Construction	25.1	33.4	47.9	35.7	36.6	38.9	26.4	48.0	58.7	53.9	60.9
Machinery	115.9	116.6	152.2	160.9	220.2	240.9	242.4	299.7	383.4	402.3	429.5
Total	141.0	150.0	200.1	196.6	256.8	279.8	268.8	347.7	442.1	456.2	490.4
Total capital and repair	489.4	519.4	570.1	589.9	742.7	1,110.4	927.5	946.1	1,009.6	1,157.1	1,450.6
Nonmetal mines[2]											
Capital											
Construction	106.7	121.1	110.2	128.1	107.9	84.6	59.8	67.5	116.0	110.5	140.2
Machinery	68.9	85.4	128.4	113.9	115.9	105.6	81.3	79.7	125.7	188.3	204.9
Total	175.6	206.5	238.6	242.0	223.8	190.2	141.1	147.2	241.7	298.8	345.1
Repair											
Construction	3.4	4.5	4.3	10.4	7.1	7.9	6.2	6.5	13.1	12.3	23.2
Machinery	49.4	57.0	57.5	64.7	99.9	107.1	116.4	135.2	167.0	168.0	196.6
Total	52.8	61.5	61.8	75.1	107.0	115.0	122.6	141.7	180.1	180.3	219.8
Total capital and repair	228.4	268.0	300.4	317.1	330.8	305.2	263.7	288.9	421.8	479.1	564.9
Mineral fuels											
Capital											
Construction	450.0	403.0	407.4	465.3	552.6	639.4	729.3	851.7	1,060.9	1,411.3	1,953.6
Machinery	55.8	71.8	58.0	76.6	86.2	101.3	91.2	83.4	165.3	211.2	194.5
Total	505.8	474.8	465.4	541.9	638.8	740.7	820.5	935.1	1,226.2	1,622.5	2,148.1

Table 67. (concl'd)

	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975[p]	1976[f]
						($ million)					
Repair											
Construction	28.6	34.2	56.3	73.7	93.5	102.7	106.8	138.0	159.0	169.2	200.9
Machinery	21.3	14.7	19.2	19.0	22.5	28.7	35.6	54.2	62.3	70.4	81.6
Total	49.9	48.9	75.5	92.7	116.0	131.4	142.4	192.2	221.3	239.6	282.5
Total capital and repair	555.7	523.7	540.9	634.6	754.8	872.1	962.9	1,127.3	1,447.5	1,862.1	2,430.6
Total mining											
Capital											
Construction	766.6	762.2	782.4	888.5	996.1	1,314.8	1,134.8	1,276.3	1,586.5	2,000.2	2,753.0
Machinery	263.2	288.5	291.6	288.7	352.4	446.7	485.5	404.4	448.9	622.0	700.4
Total	1,029.8	1,050.7	1,074.0	1,177.2	1,348.5	1,761.5	1,620.3	1,680.7	2,035.4	2,622.2	3,453.4
Repair `											
Construction	57.1	72.1	108.5	119.8	137.2	149.5	139.4	192.5	230.8	235.4	285.0
Machinery	186.6	188.3	228.9	244.6	342.6	376.7	394.4	489.1	612.7	640.7	707.7
Total	243.7	260.4	337.4	364.4	479.8	526.2	533.8	681.6	843.5	876.1	992.7
Total capital and repair	1,273.5	1,311.1	1,411.4	1,541.6	1,828.3	2,287.7	2,154.1	2,362.3	2,878.9	3,498.3	4,446.1

[1] Does not include cement, lime and clay products (domestic clays) manufacturing, smelting and refining. [2] Includes coal mines, asbestos, gypsum, salt, potash, miscellaneous nonmetals, quarrying and sand pits.
[p] Preliminary; [f] Forecast.

Table 68. Canada, capital and repair expenditures in the mineral manufacturing industries,[1] 1966-76

	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975[p]	1976[f]
						($ million)					
Primary metal industries[2]											
Capital											
Construction	85.2	82.0	77.5	71.5	114.0	89.0	95.3	75.8	148.0	170.6	163.3
Machinery	300.7	202.8	157.9	221.4	311.2	312.4	276.6	328.5	549.7	635.3	604.4
Total	385.9	284.8	235.4	292.9	425.2	401.4	371.9	404.3	697.7	805.9	767.7
Repair											
Construction	21.8	24.9	27.7	22.6	28.6	28.4	35.3	38.8	51.6	59.6	66.2
Machinery	253.4	258.1	281.4	267.9	324.6	343.5	383.2	420.1	507.3	579.5	624.4
Total	275.2	283.0	309.1	290.5	353.2	371.9	418.5	458.9	558.9	639.1	690.6
Total capital and repair	661.1	567.8	544.5	583.4	778.4	773.3	790.4	863.2	1,256.6	1,445.0	1,458.3
Nonmetallic mineral products[3]											
Capital											
Construction	50.9	39.5	19.6	37.1	30.7	21.8	30.7	37.6	29.5	38.4	55.7
Machinery	108.6	80.3	66.5	84.0	104.3	58.5	99.2	151.1	144.7	154.9	180.9
Total	159.5	119.8	86.1	121.1	135.0	80.3	129.9	188.7	174.2	193.3	236.6
Repair											
Construction	7.2	9.3	7.2	7.2	5.4	7.0	8.5	7.5	11.3	11.6	12.3
Machinery	72.1	63.9	73.8	72.1	77.1	80.4	85.7	112.0	130.9	131.0	139.6
Total	79.3	73.2	81.0	79.3	82.5	87.4	94.2	119.5	142.2	142.6	151.9
Total capital and repair	238.8	193.0	167.1	200.4	217.5	167.7	224.1	308.2	316.4	335.9	388.5
Petroleum and coal products											
Capital											
Construction	55.5	78.8	99.0	116.9	213.7	211.3	214.0	229.7	321.7	350.1	325.4
Machinery	9.6	21.4	28.8	12.9	17.4	20.1	29.8	89.1	107.8	105.8	114.1
Total	65.1	100.2	127.8	129.8	231.1	231.4	243.8	318.8	429.5	455.9	439.5

Table 68. (concl'd)

Repair											
Construction	32.6	36.0	46.6	52.1	51.0	51.3	61.3	71.1	83.8	94.0	104.2
Machinery	9.1	10.2	8.6	6.8	9.2	9.8	14.6	17.3	27.0	32.7	35.5
Total	41.7	46.2	55.2	58.9	60.2	61.1	75.9	88.4	110.8	126.7	139.7
Total capital and repair	106.8	146.4	183.0	188.7	291.3	292.5	319.7	407.2	540.3	582.6	579.2
Total mineral manufacturing industries											
Capital											
Construction	191.6	200.3	196.1	225.3	358.4	322.1	340.0	343.1	499.2	559.1	544.4
Machinery	418.9	304.5	253.2	318.3	432.9	391.0	405.6	568.7	802.2	896.0	899.4
Total	610.5	504.8	449.3	543.8	791.3	713.1	745.6	911.8	1,301.4	1,455.1	1,443.8
Repair											
Construction	61.6	70.2	81.5	81.9	85.0	86.7	105.1	117.4	146.7	165.2	182.7
Machinery	334.6	332.2	363.8	346.8	410.9	433.7	483.5	549.4	665.2	743.2	799.5
Total	396.2	402.4	445.3	428.7	495.9	520.4	588.6	666.8	811.9	908.4	982.2
Total capital and repair	1,006.7	907.2	894.6	972.5	1,287.2	1,233.5	1,334.2	1,578.6	2,113.3	2,363.5	2,426.0

[1]Industry groups are the same as in Table 28. [2]Includes smelting and refining. [3]Includes cement, lime and clay products manufacturing.
[p]Preliminary; [f]Forecast.

Table 69. Canada, capital expenditures in the petroleum, natural gas and allied industries,[1] 1965-76

	Petroleum and natural gas extraction[2]	Transportation including rail, water and pipelines	Marketing (chiefly outlets of oil companies)	Natural gas distribution	Petroleum and coal products industries	Natural gas processing plants	Total capital expenditures
	($ million)						
1965	381.0	112.1	55.2	72.5	40.6	41.5	702.9
1966	453.5	154.0	64.0	92.3	65.1	50.1	879.0
1967	385.1	204.9	86.8	76.4	100.2	89.7	943.1
1968	374.3	247.9	87.6	117.4	127.6	91.1	1,045.9
1969	438.1	220.6	103.6	117.0	129.8	103.8	1,112.9
1970	449.3	246.5	100.0	100.4	231.1	189.5	1,316.8
1971	489.6	352.0	99.2	115.2	231.4	251.1	1,538.5
1972	690.2	440.9	111.8	141.7	243.8	130.3	1,758.7
1973	864.8	390.9	128.0	146.3	318.8	70.3	1,919.1
1974	1,087.8	262.4	144.7	191.7	429.5	138.4	2,254.5
1975[p]	1,477.9	355.3	146.7	183.3	455.9	144.6	2,763.7
1976[f]	1,949.4	360.0	162.5	192.9	439.5	198.7	3,303.0

[1]The petroleum and natural gas industries in this table include all companies engaged in whole or in part in oil and gas activities. [2]Includes capital expenditures by oil and gas drilling contractors since 1965. Does not include expenditures for geological and geophysical operations. See also Footnote 3 to Table 66.
[p]Preliminary; [f]Forecast.

Company Index