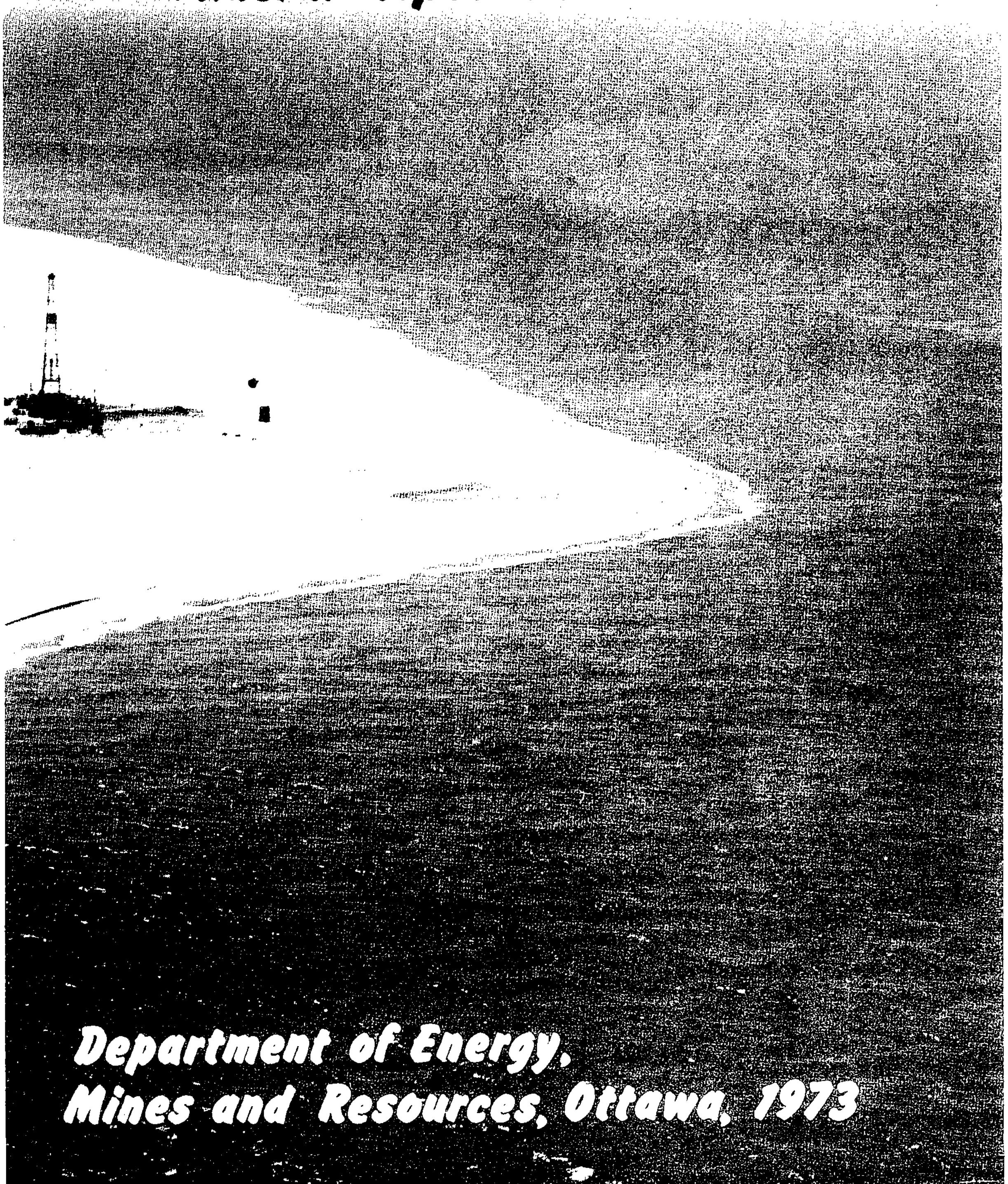
YEARBOOK 1971

Mineral Report 21



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Foreword

This issue of the Canadian Minerals Yearbook is a report of developments in the industry for 1971. The 53 chapters dealing with specific commodities, were issued in advance under the title Preprints, Canadian Minerals Yearbook 1971 to provide information as soon as possible to interested persons. The General Review, written specifically for the Yearbook each year, deals with the overall position of the industry in its national and international perspective; it is supported by 70 statistical tables not readily available from other sources. The Index to Companies 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 the Dominion Bureau of Statistics, 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.

W. Keith Buck
Director
Mineral Resources Branch

October 1972

Editor: V. Donnelly

Graphics and Cover: N. Sabolotny

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Readers wishing more recent information than that contained in the present volume should obtain the 1972 series of preprints: complete set available from Information Canada, Ottawa, $5. Individual copies are available from the Distribution Office, Mineral Resources Branch, Department of Energy, Mines and Resources, at 25¢ each.

Frontispiece:

Aerial view of the Mobil Tetco Sable Island E-48 discovery well on Sable Island, 175 miles east of Halifax, Nova Scotia. (Courtesy of Mobil Oil Canada, Ltd.)

Contents

General Review

The Canadian economy 1971

In 1971 the value of Canada's Gross National Product (GNP) reached $92 billion compared with $85.4 billion in 1970, an increase of 7.7 per cent. Figure 1 shows the growth in GNP from 1955 to 1971 and the relationship between the national product in current and in constant dollars. In terms corrected for price increases, the economy resumed the growth trend of the mid- to late sixties; that is, about 5.5 per cent a year. The actual increase in Canadian prosperity, measured by the GNP in constant dollars per head, rose from $2,991 in 1971 to $3,111, an annual rate of increase of about 4.0 per cent.

Figure 2 illustrates the real domestic product of the major industrial sectors from 1955 to 1971. The index of mining output climbed from 66 to 182.5, an annual rate of 6.6 per cent; the manufacturing index grew at 4.8 per cent a year from 82 in 1955 to 173.5 in 1971; and the agricultural index from 115 to 145.6, or 1.5 per cent a year. The manufacturing and construction indexes, which both fell in 1970 for the first time in more than a decade, resumed their growth in 1971.

The average population of Canada in 1971 was 21.8 million people. The labour force averaged 8,631 thousand, an increase of 257,000 during the year. The number of people employed increased by only 200,000 and as a result, the unemployment rate rose to 6.4 per cent, its highest since 1962. The trend in these categories between 1955 and 1971 is shown in Figure 3.

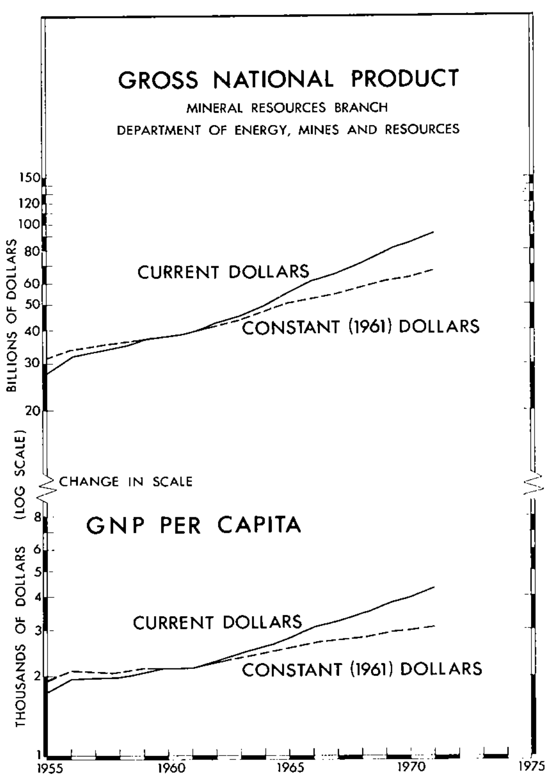


Figure 1

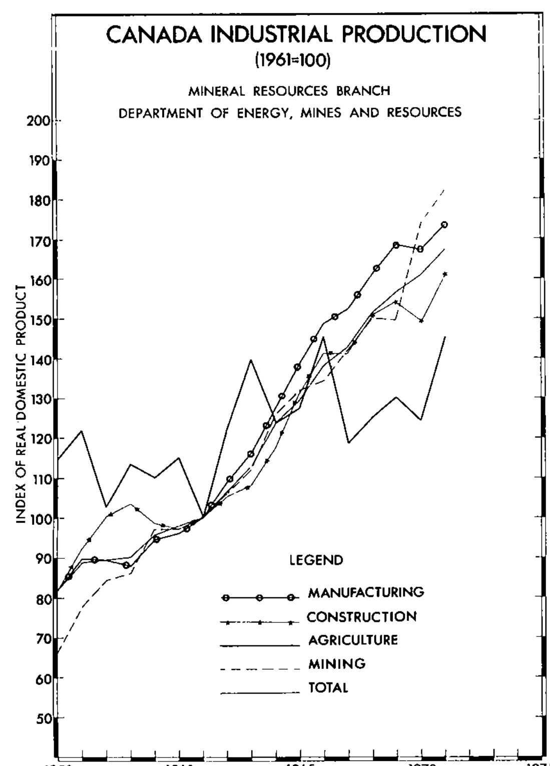


Figure 2

The General Review is compiled in the Mineral Economics Research Division of Mineral Resources Branch.

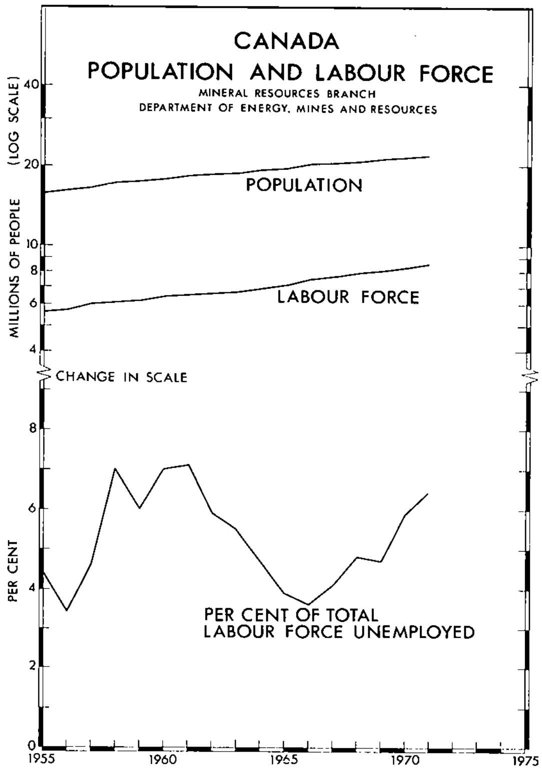


Figure 3

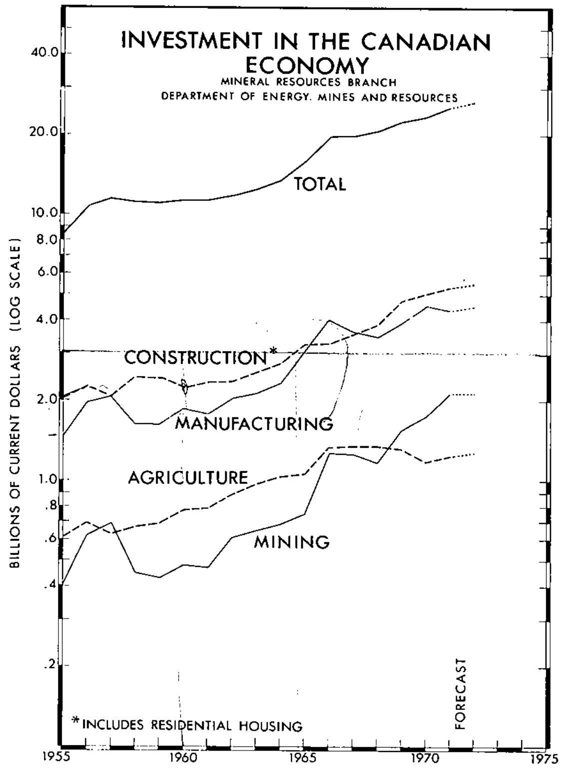


Figure 4

Total capital expenditure on plant and equipment in Canada during 1971 amounted to $25.6 billion, up $2.1 billion from 1970. Forecasts indicate that the increase from 1971 to 1972 will be around $1.6 billion. Total investment in the four major sectors of the economy are shown in Figure 4. In 1971 investment in the mining sector, which does not include the mineral manufacturing industries, rose to $2.2 billion and investment in manufacturing reached $4.4 billion, one quarter of this representing investment in mineral manufacturing.

In international trade Canadian exports increased again in 1971. Merchandise exports reached a record $17,785 million, up $1,035 million from 1970; merchandise imports also increased by $1,723 million to $15,556 million. In nonmerchandise trade or services Canadian exports increased by $81 million to $4,440 million and imports increased by $233 million to $6,603 million. These statistics represent trade in goods and services and do not include transfer payments. The trend of these four sectors is illustrated in Figure 5.

While Canadian merchandise and nonmerchandise exports increased during 1971, they were offset by the increase in imports, which led to a much lowered surplus on the total current account balance of international trade, as shown in Figure 6. Also illustrated is the continuing increase in the deficit on nonmerchandise trade composed largely of the continuous flow of interest and dividends out of Canada.

Figure 7 shows the behaviour of net capital movement in the Canadian Balance of International Payments from 1955 to 1971. The large increase in surplus of net capital movement indicates inflow of capital into Canada, which was partly responsible for the rapid growth of the mineral industry. The figure shows that in general this surplus has been decreasing since 1956.

The mineral economy

Canadian mineral production was valued at $5.9 billion in 1971, up $164 million from the revised total for 1970. Since 1955, as seen in Figure 8, total

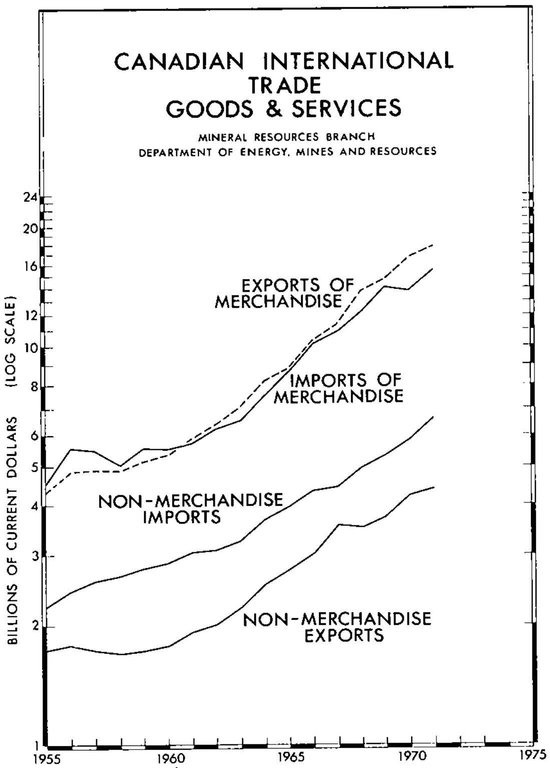


Figure 5

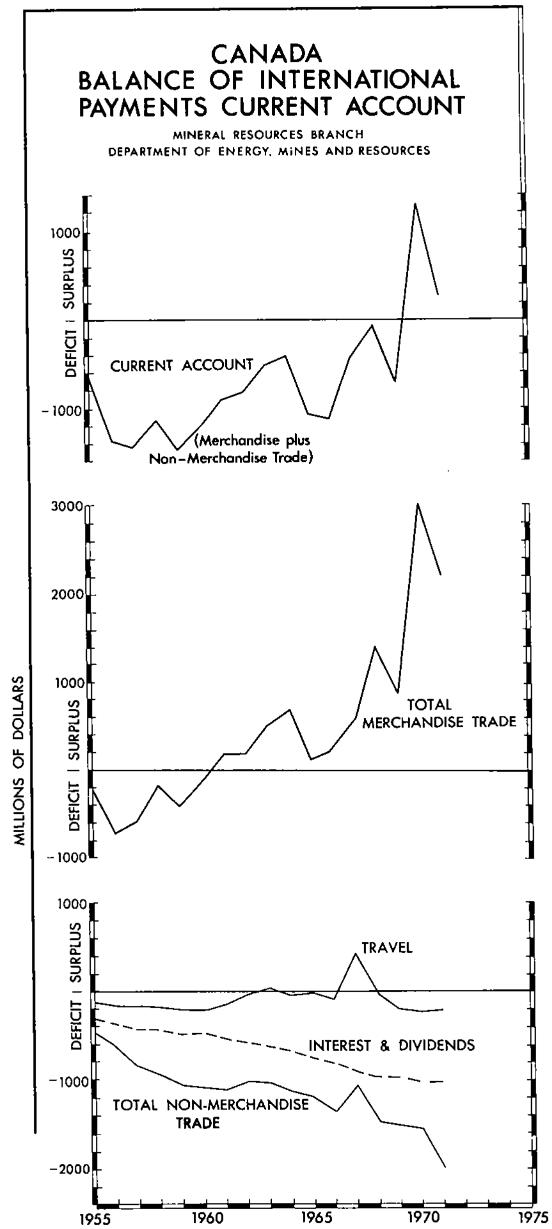


Figure 6

Canadian mineral output has grown more than threefold, at an annual rate of nearly 8 per cent. The figure also illustrates growth of the four sectors of the mineral industry. In 1971 output of metallic minerals, at $2,937 thousand, was down slightly, from $3,073 thousand in 1970. Nonmetallic and structural minerals had a combined production value of $978 thousand, up $56 thousand from the previous year. Mineral fuels output increased 17 per cent, and for the first time exceeded $2 billion.

Canada continues to enjoy the highest value of mineral industry output per head of any country with a diversified mineral economy, amounting to $273 in 1971.

Petroleum was the dominant mineral commodity in terms of value of output in 1971 with 22.5 per cent of the total (Figure 9). The four leading metals, nickel, copper, iron ore and zinc, accounted for nearly half of Canadian mineral value in 1971. Figure 9 also shows mineral production in terms of provincial output. The largest single contribution was made by Alberta, with 28.0 per cent of total mineral production; this was the first time for many years that Ontario did not provide the largest proportion. Data on absolute provincial mineral production is given in Table 6 of the statistical tables

Physical volume of output in the three sectors of the mining industry are shown in Figure 10, in the

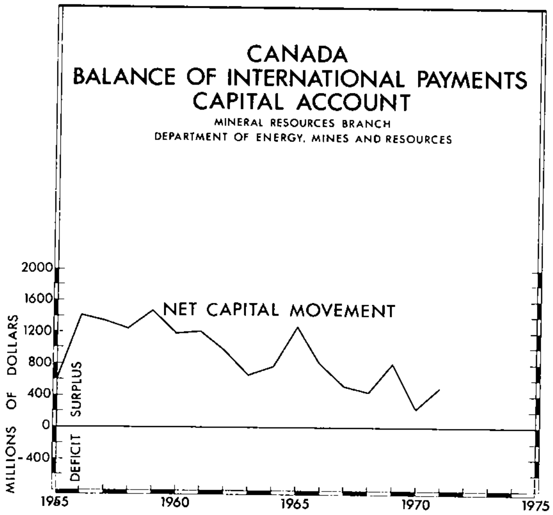


Figure 7

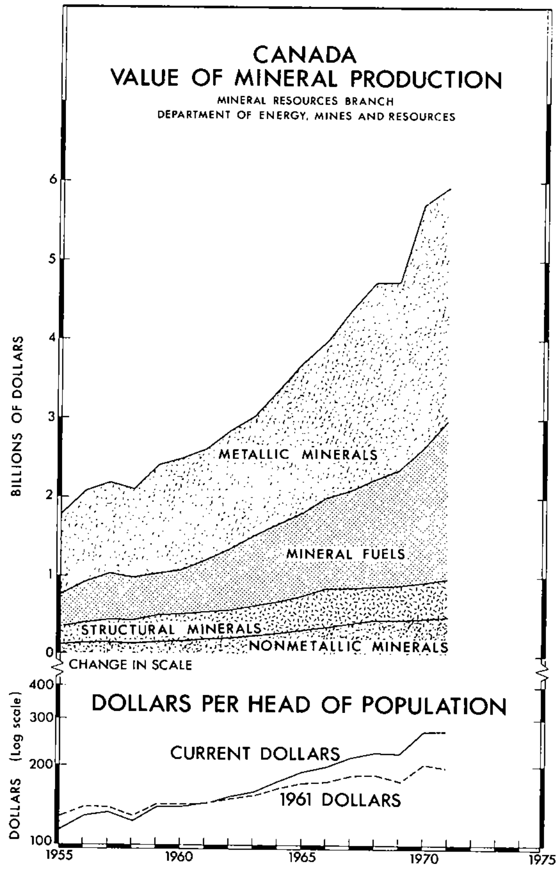


Figure 8

form of indexes, for the period 1955-1971. These indexes are published by Statistics Canada and are based on 1961 output being equivalent to 100. In terms of annual growth rates for the period shown in the diagram, the fuels sector leads with a rate of 9.1 per cent a year; nonmetal mines and metal mines follow with rates of 5.9 per cent and 5.0 per cent a year, respectively.

Capital expenditures. Capital expenditures in the Canadian mining industry have been rising steadily from about $512 million in 1960 to a forecast total of $2.2 billion in 1972. Figure 11 indicates that capital expenditures were the fastest growing in the nonmetal sector up to 1969 but fell thereafter. Growth in metal mining was very strong in 1970 and 1971 but the 1972 forecast shows a levelling off. Mineral fuels exhibit continued steady growth. Capital expenditures in the mineral manufacturing industries (Figure 12) generally followed their historical patterns, with nonmetallic mineral products forecast to recover from the low value in 1971.

Mineral trade. The value of mineral exports fell in 1971 by about $160 million from their value the previous year, to $5.039 billion. Detailed statistics on mineral trade are provided in Section 2 of the statistical tables following the reviews. Figure 13 shows that crude mineral exports are growing faster than total mineral exports. The figure also shows their relation to total merchandise exports.

The United States remained by far the most important market for Canadian mineral exports in 1971. Its share of the market returned to almost 60 per cent, after falling to 55 per cent in 1970 (Figure 14). The proportion of mineral exports to Britain continued to decline, accounting for 11.8 per cent of the total in 1971. At the same time, the proportion going to Japan continued to rise, and reached 8.8 per cent.

Review by provinces*

British Columbia. In 1971 the value of mineral production reached a record $532.7 million, a gain of 8.8 per cent over $489.8 million for the previous year. Copper continued as the leading commodity. Its production value increased significantly by 15.3 per cent and it attained its largest proportion of the total output, 26.6 per cent. It was followed by crude petroleum which decreased slightly and represented 11.3 per cent of the total. Structural materials

*Compiled in Research and Planning Division.

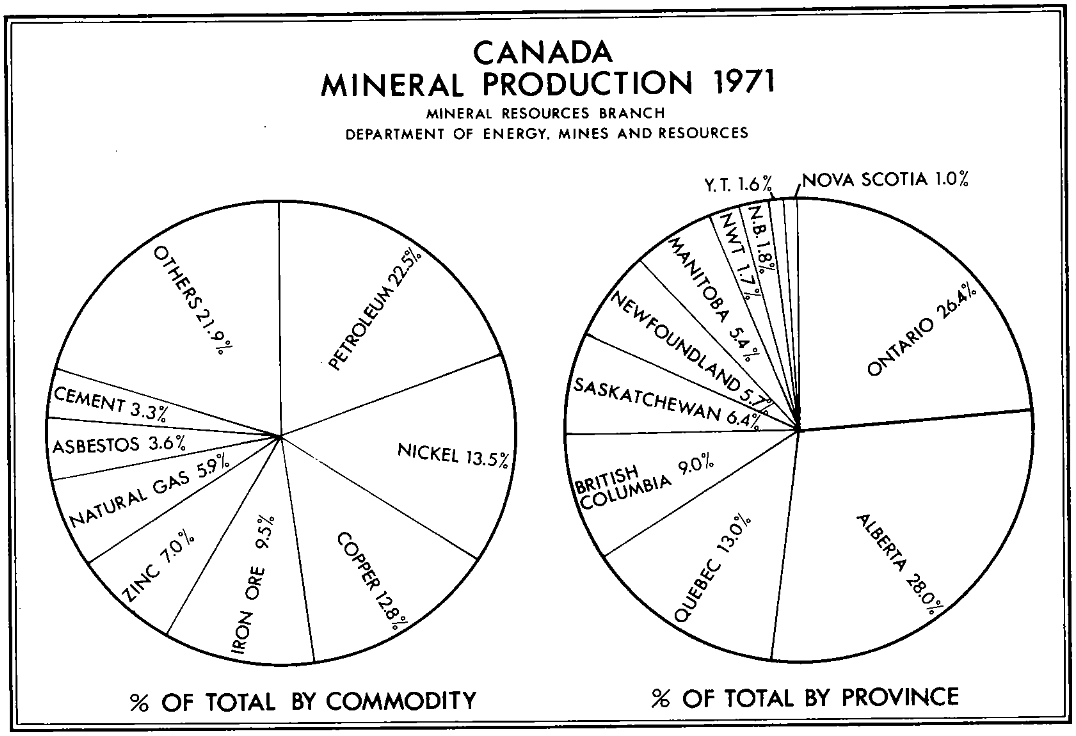


Figure 9

increased by 19.8 per cent to attain third place in mineral production value. Zinc production accounted for 9.4 per cent. Production of molybdenum fell off 13.9 per cent in value to account for 8.5 per cent. This province is responsible for Canada being the second largest world producer of molybdenum.

During 1971 four copper mines began production, including Giant Mascot Mines Limited's nickel-copper mine near Hope, which had ceased operation because of a fire in 1970, and the Sunro mine on Vancouver Island, which was closed in the sixties by flooding.

Eight mines suspended operations and closed during 1971, among them two gold and two molybdenum producers, two copper producers and two lead-zinc producers. To more than compensate for these losses, six new copper orebodies are being prepared for production, anticipated in 1972. Lornex Mining Corporation Ltd., a subsidiary of Rio Algom Mines Limited, and Gibraltar Mines Ltd., a subsidiary of Placer Development Limited, will each have production capacities in excess of 30,000 tons a day. Logan Lake, a new town to serve the Lornex development, has been established 40 miles from Kamloops and 250 miles northeast of Vancouver. Similkameen Mining Company Limited, a subsidiary of Newmont Mining Corporation, will produce 15,000 and the Bell mine of Noranda Mines Limited 10,000 tons a day. Alwin Mining Company Ltd. and Nadina Explorations Limited will each have plants to treat 500 tons a day.

Although there were no major developments in crude petroleum and natural gas, production continued at the same level as last year, dropping slightly for crude petroleum and increasing slightly for natural gas. Owing to an improvement in the demand for zinc, the value of zinc output increased in 1971. Cominco Ltd. mined most of the province's zinc and lead and this production, along with concentrates from many other mines throughout Canada, is converted at the company's metallurgical plants to refined zinc, lead and silver and the byproducts antimony, bismuth, cadmium, tin, iron and sulphur compounds.

The coal mining industry of the province continued to increase in production during the year. The quantity of coal mined increased by 33 per cent over the previous year. Most of the province's coal

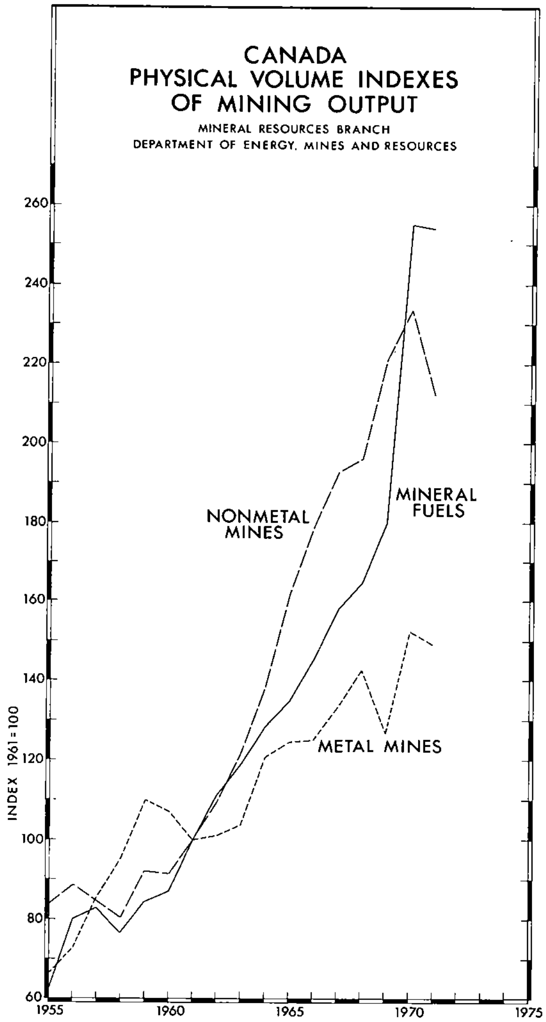


Figure 10

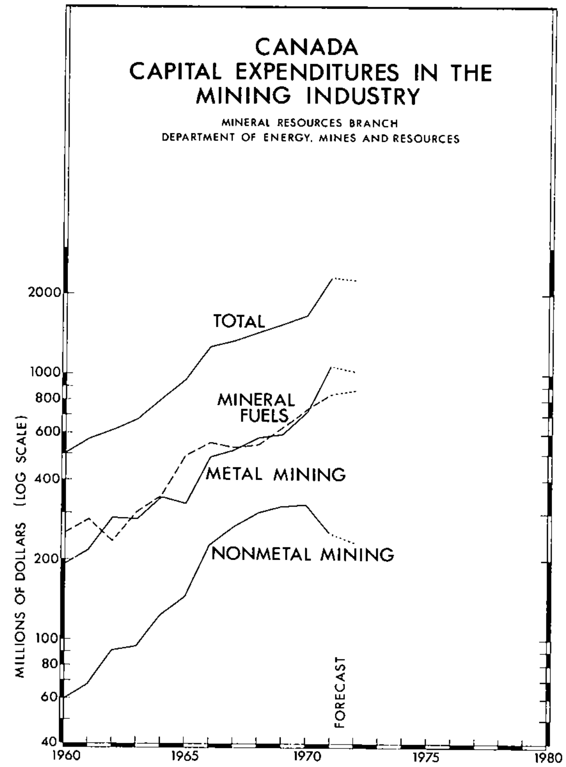


Figure 11

output will continue to be exported to Japan for metallurgical purposes. The continuing development of coal mining and its related transportation facilities will have a long-term buoyant effect on the economy of western Canada.

Yukon Territory and Northwest Territories. The value of mineral production in the Yukon Territory increased substantially to $94.0 million from $77.5 million recorded in 1970. Almost 85 per cent of the value of production was provided by the metallic minerals sector mostly through the output of zinc and lead, which increased almost 50 per cent in value. Most of this increase was the result of a 20 per cent expansion in mill capacity of the zinc-lead operation of Anvil Mining Corporation Limited at Ross River in 1971. The entire output is exported chiefly to Japan. This development also contributed to a significant rise in the shipments of silver, increasing 16.4 per cent in value over 1970. Copper shipments declined 70.6 per cent in value because of the shutdown of the mill of New Imperial Mines Ltd. (name changed to Whitehorse Copper Mines Ltd.) at Whitehorse in June 1971. Also in June 1971 Venus Mines Ltd. suspended operations at its silver-lead-zinc mine at Carcross. Nonmetallic mineral production was represented by asbestos shipped from the Clinton Creek operation of Cassiar Asbestos Corporation Limited. Shipments of asbestos declined slightly in total value but production levels were maintained.

In the Northwest Territories, mineral output declined in value to $99.5 million from $133.8 million in 1970. Metallic minerals accounted for almost all the production. Zinc and lead, the leading commodities, comprised 86.1 per cent of the output value and were produced in lower amounts from the Pine Point area

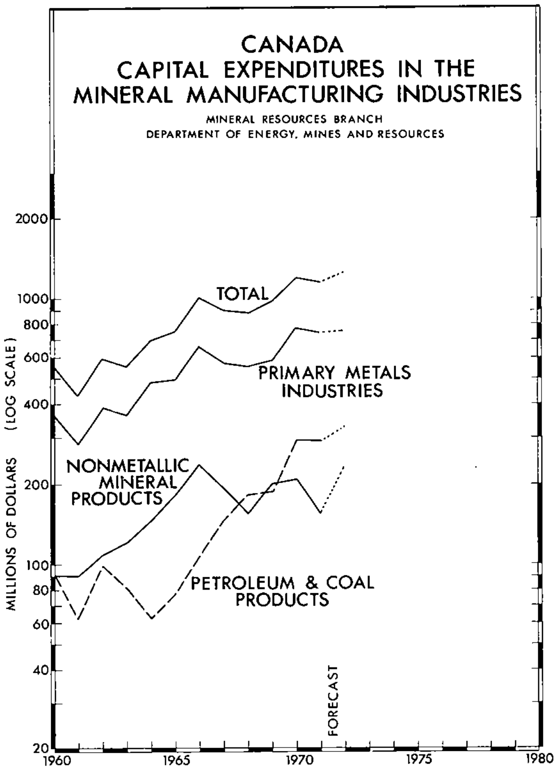


Figure 12

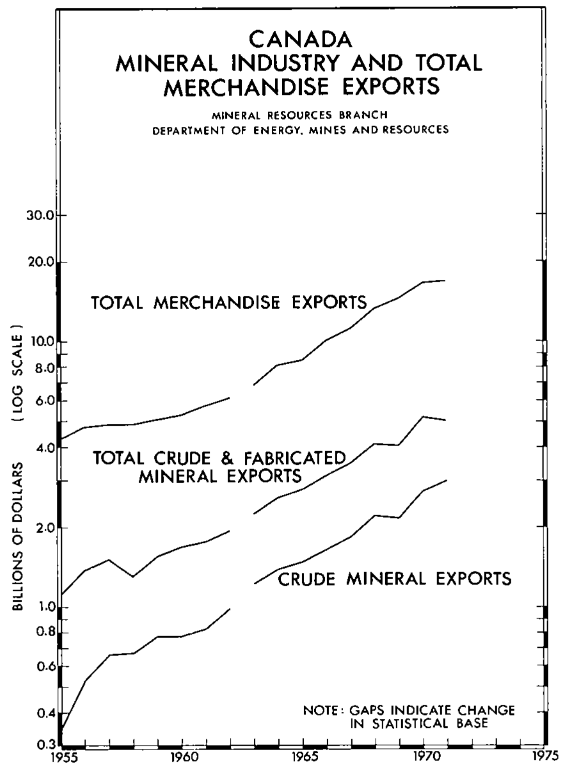


Figure 13

south of Great Slave Lake by Pine Point Mines Limited, a subsidiary of Cominco Ltd. Shipments of zinc, at $61.9 million, accounted for 63.1 per cent of the total value of minerals. During the year, the Northwest Territories fell to third place among the lead-producing regions of Canada and recorded a drop in shipments. Gold output from mines in the Yellowknife area continued to decrease in value to $10.8 million. Likewise, the value of silver production declined from $5.1 million in 1970 to $2.7 million in 1971.

The fifth-leading commodity, crude petroleum, represented 1.3 per cent of the production value but, along with natural gas, it has spurred considerable exploration activity, particularly on the Arctic islands and near the Arctic coast.

Alberta. This province became the leading mineral-producing region in Canada in 1971 in terms of value of production. It increased the value of mineral output by 17.0 per cent over that of 1970 to a total of $1,657.8 million and continued as the leading producer of crude petroleum, natural gas and its byproducts, and elemental sulphur. Those commodities accounted for 94.1 per cent of the total value. Crude petroleum increased significantly the list at $1,050.9 million and providing 64.4 per cent of the total. Natural gas and natural gas byproducts were next in importance and experienced substantial gains to $294.0 and $196.4 million, respectively. The production value of structural materials reversed its trend and increased slightly in 1971. The value of sulphur shipments was again down in 1971. It declined by 27.6 per cent as a result of extremely low prices caused mainly by international oversupply. The value of coal output increased 82.8 per cent and Alberta continued as the largest national producer of this commodity. Continued significant increases are anticipated from coal deposits in the western part of the province, mainly due to the Japanese demand for metallurgical-grade coal.

Petroleum exploration activity has declined in western Canada as interest and activity have shifted to northern and offshore areas. Alberta's reserves

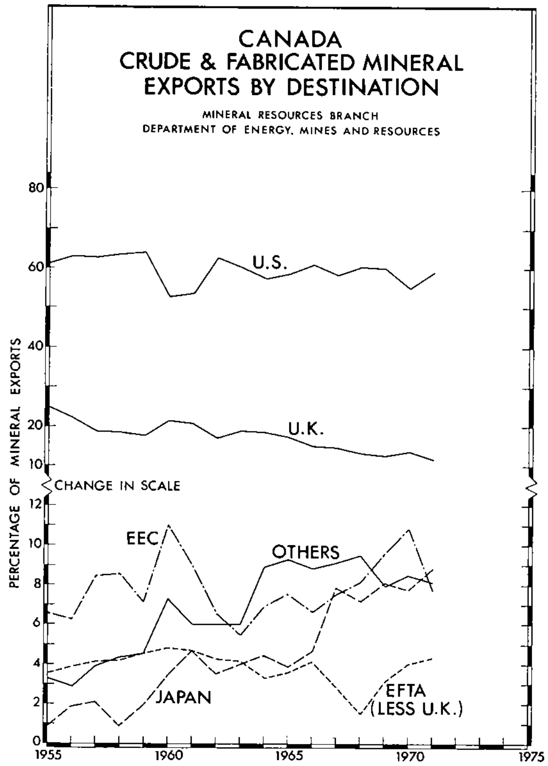


Figure 14

production ratio is declining, indicating a consumption rate greater than the discovery rate. As a move to increase refining efficiency, both Imperial Oil Limited and Gulf Oil Canada Limited have undertaken to construct consolidated refining facilities at Edmonton. This program started in 1971. Older small refineries in various centres in Manitoba, Saskatchewan and Alberta will be phased out.

Saskatchewan. Saskatchewan's mineral production reached $378.7 million in 1971, down 0.09 per cent from 1970. Some mineral commodities experienced significant advances or reverses compared with the previous year. Crude petroleum, the leading commodity, had a slight reversal in value to $198.1 million and represented 52.3 per cent of the total. Potash followed in order of value and increased 17.8 per cent over its 1970 output to account for 33.8 per cent of the provincial total. This province provides all of Canada's potash and is responsible for this country being the leading world producer.

Structural materials, next in importance, increased 10.7 per cent in value and accounted for 3.0 per cent of the provincial total. Natural gas moved up to fourth place, increasing 22.4 per cent to account for 2.4 per cent. Copper suffered a major decline of 64.1 per cent and accounted for 2.1 per cent. This decline was caused by labour strikes from January to July and production should regain former levels in 1972. The production of coal fell off during the year accounting for 1.7 per cent of the total value of provincial mineral production. The quantity of uranium produced dropped by 26.6 per cent from 1970 during the third year of a five-year program of Eldorado Nuclear Limited to reduce production from the Beaverlodge area. Production will eventually be decreased to 50 per cent of rated capacity in order to closely correspond to sales commitments. During the year work began on the $50-million uranium mining project of Gulf Minerals Canada Limited at Rabbit Lake with a tentative production date of late 1974. The Saskatchewan Government has indicated that it will build a $17-million all-weather road to the site, and is also considering plans for a townsite at nearby Wollaston Lake.

Manitoba. The value of mineral output from Manitoba reached $319.6 million in 1971, a decline of 3.6 per cent over the previous year. The two leading commodities, nickel and copper, which were valued at $203.3 million and $59.6 million, respectively, accounted for 82.2 per cent of the total mineral value. Nickel production value declined 5.4 per cent whereas copper production value increased 7.2 per cent. There was an increase of 6.5 per cent in the output of structural material and a decline of 5.2 per cent in the output of crude petroleum, the two commodities next in importance. A labour strike affected the production of zinc. Its value of production fell 33.1 per cent compared with 1970. Other mineral commodities such as tantalum, cobalt and gold, in that order, contributed slightly to the value of provincial mineral output.

The International Nickel Company of Canada, Limited (Inco) operated two nickel mines, a smelter and a refinery in the Thompson area. Sherritt Gordon Mines, Limited continued to ship nickel and copper from its Lynn Lake operation and copper-zinc from Fox Lake. Development continued at Sherritt's Ruttan Lake copper-zinc deposit about 140 miles northeast of Flin Flon. Production is planned for July 1973 at a rate of 10,000 tons a day.

Manitoba's newest mine, Manibridge Mine, was officially opened in September 1971. The mine is sixteen miles from Wabowden and is owned and operated by Falconbridge Nickel Mines Limited. This is Falconbridge's first producer outside its Sudbury Basin home territory. Nickel and copper concentrates from Manibridge will travel by rail to Falconbridge's smelter at Falconbridge, Ontario.

Hudson Bay Mining and Smelting Co., Limited operated seven copper-zinc mines in the province. The mineral concentrates shipped from these mines are smelted and refined, along with concentrates received on a custom basis, at the company's copper-zinc smelter at Flin Flon. Considerable exploration for metallic minerals continued in the north, particularly in the Thompson area.

Ontario. The value of Ontario's mineral production declined by $26.5 million in 1971, reaching a total of $1,563.4 million. This was in contrast to 1970, when it registered a 30.0 per cent gain. During 1971 nickel and copper accounted for 58.2 per cent of the total value of the province's mineral output. The value of nickel declined 3.2 per cent to $588.8 million and the value of copper declined 5.9 per cent to $320.6 million. In decreasing order of value, the other leading mineral commodities were structural materials, iron ore, zinc, platinum metals, gold and silver.

During 1971 a silver refinery at Cobalt was closed, nickel production was cut back because of accumulating world stockpiles, the planned expansion of an iron mine in southern Ontario was suspended, and three gold mines terminated operations. The copper-nickel mine of Texmont Mines Limited at Timmins began production in June. Also at Timmins, the construction of a zinc smelter-refinery complex, commenced in May 1970, was completed by Ecstall Mining Limited and placed in operation in April 1972 at a cost of $50 million. It will process about half the zinc concentrates formerly exported from the province. Sulphuric acid and cadmium will be byproducts of the operation. At Sudbury the first nickel refinery to be built in the area neared completion. Production at this Inco refinery, utilizing new processes, will be delayed until 1973.

Many other mineral commodities are produced in Ontario, which supplies a greater variety than any other province. The north continues to provide significant exploration activity and additional new discoveries are being explored or developed for production.

Quebec. The production value of minerals in Quebec declined by 3.9 per cent. Copper continued to be the dominant commodity and its value provided 25.7 per cent of the province's total value, or $197.5 million. This was a decline of 1.5 per cent from the 1970 value. Contributing to this decline was the closure of the Quemont mine in the Rouyn-Noranda district in July because of ore depletion. On the other hand Noranda Mines Limited undertook a $133 million expansion program in the spring to increase its copper production in Quebec. Most of these funds will be expended by Noranda's subsidiary Gaspe Copper Mines, Limited at Murdochville.

Asbestos was the mineral commodity second in importance and provided 20.6 per cent of the provincial value of mineral production. The total value of asbestos production declined 1.9 per cent from the previous year. One asbestos mine, Flintkote Mines Limited at Thetford Mines ceased operation in December because it lacked reserves. However considerable expansion activity was under way at the existing operations of Canadian Johns-Manville Company, Limited, Bell Asbestos Mines, Ltd. and the King-Beaver operation of Asbestos Corporation Limited. In addition, Asbestos Corporation continued to develop the Penhale property and the Asbestos Hill deposit near Ungava Bay for production. These developments will assure Quebec's continued world prominence as a source of asbestos.

Structural materials increased substantially over last year and accounted for 14.8 per cent of the province's value of mineral production. Iron ore output accounted for 14.6 per cent of the value of mineral output. This was a decline of 15.8 per cent from the previous year. Two major projects announced for Quebec in 1970 were under way: Iron Ore Company of Canada was constructing a new concentrator and pellet plant at Sept-Îles and Quebec Cartier Mining Company was constructing a concentrator at Mt. Wright. Quebec Cartier will construct a new town to be known as Fermont for a population of 5,000. The town will be distinctively designed for northern latitudes. The expenditure for these projects will be around $440 million over the next few years and will provide many permanent and temporary jobs, as well as a major increase in the production of iron ore pellets. These new developments are mainly the result of increased world demand for iron ore.

Other leading commodities were zinc, titanium dioxide and gold, in that order. Quebec produces many other mineral commodities and has pioneered such industries as those relating to titanium dioxide, columbium and lithium. Intense exploration activity relating to a diversity of minerals continued during 1971. The large areas of potential mineral wealth, some relatively unexplored, will assure a continuing significant level of mining activity.

New Brunswick. The mineral output of New Brunswick is closely related to the production of zinc and its coproducts. In 1971 the total value of mineral production increased by 2.9 per cent from the previous year to a total of $107.4 million. Zinc accounted for approximately half the total and, along with its coproducts lead, copper, silver, cadmium, bismuth and gold, it represented 75.5 per cent of the total mineral value. The value of zinc and copper output was up 4.0 and 12.9 per cent, respectively, whereas the value of lead and silver declined 2.8 and 7.7 per cent. The production of structural materials, the fourth-leading commodity following zinc, lead and copper, was up marginally and accounted for 8.0 per cent of the total value. Coal output from the declining Minto coalfields increased significantly by 38.3 per cent to account for 3.8 per cent of the provincial total.

Brunswick Mining and Smelting Corporation Limited is the province's largest producer of base metals and operated two zinc-lead-copper mines and two mills near Bathurst; a related company, East Coast Smelting and Chemical Company Limited, operated a zinc-lead smelter at Belledune. Another important base metals producer is Heath Steele Mines Limited with mines located northwest of Newcastle. The Caribou copper mine of The Anaconda Company (Canada) Ltd., which began production late in 1970, was closed in November 1971. Consolidated Durham Mines & Resources Limited constructed a 400-ton-a-day concentrator at its Lake George antimony property as it prepared for production late in the year, and the first contract for the sale of antimony concentrates was with AMMI, an Italian state-owned company.

Potash was discovered near Sussex during the year as a result of drilling which was part of a mineral exploration program funded by the federal Department of Regional Economic Expansion. This discovery has attracted much interest and many firms have made development proposals.

Nova Scotia. Nova Scotia's mineral output was valued at $60.1 million in 1971, a 5.6 per cent increase over 1970. Over 99 per cent of the total was provided by fuels, structural materials and nonmetallic minerals. Coal, the leading commodity, accounted for 38.9 per cent and increased 7.2 per cent to $23.4 million. This was due to increases in prices, as the actual quantity produced in 1971 was less than the quantity produced in 1970. Two coal mines closed during the year, Springhill Coal Mines Limited and the No. 20 mine of Cape Breton Development Corporation (Devco). The large Lingan coal mine in the Sydney area was being developed by Devco.

Structural materials increased slightly in value from 1970 and accounted for 25.6 per cent of the provincial total. Gypsum retained its position and provided 17.8 per cent of the value. Nova Scotia provides about 71 per cent of Canada's gypsum and is one of the leading gypsum-producing areas in the world. The value of salt output increased significantly to provide 15.3 per cent of the province's value of production. Barite and lead shipments were relatively small and both were considerably reduced in 1971.

The first important discovery of oil and gas off the Canadian east coast was made by Mobil Oil Canada, Ltd. and Texas Eastern Transmission Corporation at their well on the western tip of Sable Island, 175 miles east of Halifax. The discovery well is reported to have twelve zones which flowed both natural gas and condensate at rates up to 10.6 million cubic feet a day of gas and 1,600 barrels a day of condensates on tests. Four zones flowed crude oil at rates of 367 barrels a day to 574 barrels a day with small associated gas flows. An estimated $100 million was expended in oil exploration off the east coast in 1971.

Prince Edward Island. Prince Edward Island's mineral production has historically been confined to structural materials. The value of production in 1971 increased 1.6 per cent to $650,000 and was confined solely to the output of sand and gravel.

Newfoundland and Labrador. Newfoundland is by far the largest producer of iron ore in Canada. The mines and concentrators are operated by Iron Ore Company of Canada and Wabush Mines. During the year Iron Ore Company began a 12,000,000 ton-a-year expansion of its Labrador City operation. Iron ore continued to play a major role in the mineral industry of Newfoundland and although the value of production declined almost 2 per cent it accounted for 85.3 per cent of the total value of provincial mineral production. Newfoundland's total mineral production was valued at $336.7 million in 1971, a decline from $353.2 million in 1970.

Asbestos, the mineral commodity second in value of output, increased in value by 20 per cent to account for 4.2 per cent of the provincial total. Improvements in mining, cost control and equipment replacement were largely responsible for improved production at the province's only asbestos operation, Advocate Mines Limited, located at Baie Verte.

Copper declined 22.9 per cent to account for 4.0 per cent of the provincial total. Copper production, along with zinc and lead which also sustained production losses, was affected by a labour strike from June to November at the Buchans Unit of American Smelting and Refining Company. Also in December, the copper mine of First Maritime Mining Corporation Limited at Gull Pond suspended operations. The Ming copper-gold-silver orebody, discovered in 1970 a mile or so north of the main operation of Consolidated Rambler Mines Limited at Baie Verte was brought into production, renewing the life of this mining operation.

In September 1971, the governments of Newfoundland and Labrador and Canada signed a separate agreement for mineral development, the total cost of which will be $2,698,000 over four years. This agreement is funded by the Federal Government through the Department of Energy, Mines and Resources and by the Department of Regional Economic Expansion on an equal basis. The program will consist of six major projects concerned with provincial mineral evaluation and development.

Lightweight Aggregates

D.H. STONEHOUSE

Traditional aggregates for use in concrete and concrete products have been sand and gravel. As concrete technology advanced, 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 subject of ongoing studies and research in conjunction with the use of various types of cement as the binding media. Until the mid-forties 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 volume, 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 enabled the construction of much taller buildings and the use of longer clear spans.

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 or slates. Ultralightweights 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. Byproduct aggregates are obtained from the combustion of coal and coke and include slag and fly ash.

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 South Africa; perlite is imported mainly from New Mexico and Colorado and pumice is imported from the State of Oregon and from Greece.

Canadian industry and developments

With total construction spending in Canada showing continued increases (from $13.8 billion in 1970 to $15.6 billion in 1971 and estimated to reach $16.3 billion in 1972) and with the general trend towards higher buildings, larger precast shapes and greater clear spans, the application of lightweight aggregates in concrete should increase greatly. The location and cost advantages enjoyed by the normal heavy aggregates are becoming less of a factor as sources of good-quality aggregates close to the consuming centres are becoming scarce and land-use conflicts are more evident.

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.

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.

Table 1. Canada, production of lightweight aggregates, 1970-71

	1970		1971	
	(cu yd)	($)	(cu yd)	($)
From domestic raw materials				
Expanded clay, shale and slag	725,169	3,512,700	780,376	4,014,160
From imported raw materials				
Exfoliated vermiculite	301,500	2,935,400	300,519	3,128,216
Expanded perlite	73,800	824,200	103,155	1,117,062
Pumice	..	90,000	30,100	173,000
Total	1,100,469[1]	7,362,300	1,214,150	8,432,438

Source: Company data. .. Not available. [1]Total of available data only.

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, when it will then 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.

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 four and twenty 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 the feed to the kiln and the retention time in the flame.

Table 2. Canada, consumption of expanded clay and shale

	1969	1970	1971
	(%)	(%)	(%)
Concrete			
Block	68	61	69
Precast structural	2	5	3
Cast-in-place structural	29	30	27
Minor uses			
Sand blasting, horticulture, refractories, insulation, brick grog, flexible pavement	1	4	1

Source: Company data.

Whereas pumice is more closely associated with concrete products manufacture in Canada, perlite is imported, expanded and used by gypsum products manufacturers. In 1971 about 64 per cent of consumption was in plaster products such as wallboard or drywall, where its value as a lightweight material is augmented by its fire-resistant qualities. It is also used as a loose insulation and to a much lesser degree as an insulating medium in concrete products. Agricultural uses are increasing as perlite, along with vermiculite and expanded shale and clay, is more widely used as a soil conditioner and fertilizer carrier.

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 1971 seven companies at eight locations in Canada reported production of expanded perlite.

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

Vermiculite. The term vermiculite refers to a group of micaceous minerals, hydrous magnesium-aluminum silicates, that exhibit a characteristic lamellar structure and basal cleavage and that expand or exfoliate greatly

Table 3. Canada, consumption of expanded perlite

	1969	1970	1971
	(%)	(%)	(%)
Insulating plaster	52	62	64
Insulation	34	17	22
Insulating concrete	4	7	3
Minor uses: fillers			
Agriculture, horticulture	10	14	11

Source: Company data.

Table 4. Canada, consumption of exfoliated vermiculite

	1969	1970	1971
	(%)	(%)	(%)
Loose insulation	71	63	72
Insulating plaster	11	14	9
Insulating concrete	7	11	10
Minor uses			
Fireproofing, agriculture, underground pipe insulation, horticulture, barbecue base	11	12	9

Source: Company data.

upon being rapidly heated. Mining is normally by open-pit methods and benefication 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 because of the high costs associated with shipping a high-bulk, low-weight commodity such as the 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 are put are dependent on its low thermal conductivity, its fire-resistance and more recently on its lightweight qualities.

Table 5. Lightweight aggregate plants in Canada, 1971

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
Miron Company Ltd.	Montreal	Pumice[1]
Perlite Industries Reg'd.	Ville-St-Pierre	Perlite
Vermiculite Insulating Limited	Lachine	Vermiculite
Ontario		
Canadian Gypsum Company, Limited	Hagersville	Perlite
Domtar Construction Materials Ltd.	Caldonia	Perlite
	Cooksville	Expanded shale
F. Hyde & Company, Limited	St. Thomas	Vermiculite
Holmes Insulations Limited	Sarnia	Perlite
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
Edmonton Concrete Block Co. Ltd.	Edmonton, Alta.	Expanded clay
Grace Construction Materials Ltd.	Winnipeg, Man.	Vermiculite
	Regina, Sask.	Vermiculite
	Edmonton, Alta.	Vermiculite[2]
	Calgary, Alta.	Vermiculite[2]
Kildonan Concrete Products Ltd.	St. Boniface, Man.	Expanded clay
Northern Perlite & Vermiculite Products	St. Boniface, Man.	Perlite
		Vermiculite
Redi-Mix Concrete Ltd.	Regina, Sask.	Expanded clay
British Columbia		
British Columbia Lightweight Aggregates Ltd.	Saturna Island	Expanded shale
Grace Construction Materials Ltd.	Vancouver	Vermiculite
Ocean Cement Limited	Vancouver	Pumice[1]
Westroc Industries Limited	Vancouver	Perlite
		Vermiculite

Source: Company data.
[1] Pumice is used in concrete block manufacture.
[2] Calgary plant closed December 1971. Edmonton plant opened December 1971.

Canadian consumption is mainly as loose insulating material with smaller amounts being used as aggregate in insulating plaster and concrete. The major producer of vermiculite is the United States; the principal company supplying Canada's imports is W. R. Grace & Company with operations at Libby, Montana. Canada also imports crude vermiculite from South Africa where Palabora Mining Co. Ltd. is a major producer.

The Geological Survey of Canada reports occurrences of vermiculite in British Columbia and in Ontario but as yet no commercial deposits have been developed in Canada.

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 1920's in Ontario, it did not evolve significantly until the 1950's 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. Clay receives little beneficiation other than drying before being introduced to the kiln. Shales are crushed and screened before burning. Nine plants in Canada currently produce lightweight aggregates from clay and shale, using a rotary kiln process.

One company produces an aggregate material from slag as a byproduct of a blast furnace operation. The statistics relative to expanded slag production are included with those of clay and shale. In the steelmaking process, 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.

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 raw material could become of increasing importance. An Alberta firm is producing brick using fly ash and bottom ash as raw material.

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

Aluminum

D.G. SCHELL

Although demand for aluminum made a good recovery in North America in 1971, consumption in Europe weakened and that in Japan increased much more slowly than in previous years. Supply exceeded demand and price reductions, particularly of primary aluminum, were general. The outlook is for gradually improving consumption and prices but overproduction still is a threat.

Canadian industry

The main ore of aluminum, bauxite, has not been found in economic concentrations in Canada and must be imported. Occurrences, of mineralogical interest only, have been noted at Steep Rock Lake near Atikokan, Ontario and at Sooke, British Columbia. Alumina is extracted from bauxite by the Bayer process whereby bauxite is selectively leached or 'digested' by hot caustic soda solution, alumina trihydrate is precipitated, then filtered, washed, dried and calcined to form alumina (Al_2O_3) of the high purity required for reduction to aluminum. The Hall-Heroult process is used to reduce alumina to aluminum metal. This process takes place in an electric furnace or 'pot' consisting of a refractory-lined steel box with an inner liner of carbon. About 150 of these furnaces, connected in series, make up a 'potline'. Direct current is passed through a fused bath of alumina dissolved in cryolite (Na_3AlF_6). Molten aluminum settles in the bottom of the furnace and is removed. Approximately 4 tons of bauxite make 2 tons of alumina, which in turn are reduced to 1 ton of aluminum. The Hall-Heroult process consumes vast quantities of electric power, between 7 and 8 kwh per pound of aluminum produced, and Canada's aluminum smelters are advantageously located near large, low-cost power sources. 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. Primary aluminum production in Canada was 1,120,951 tons* in 1971, an increase of 4.6 per cent over 1970. Two companies operate primary aluminum smelters in Canada, The Aluminum Company of Canada, Limited (Alcan), a subsidiary of Alcan Aluminium Limited, of Montreal, and Canadian Reynolds Metals Company Limited, a subsidiary of Reynolds Metals Company of Richmond, Virginia. The year 1971 was noted for cutbacks in production as the year progressed. Alcan was operating at an average of 91 per cent of capacity during the year and 86 per cent at year-end, whereas Reynolds was at 90 per cent and 83 per cent. Capacity of Canada's aluminum smelters is shown in Table 5.

Alcan's five Canadian smelters produced 945,000 tons of aluminum, a modest 5 per cent increase compared with 903,000 tons in 1970, when a strike caused the shutdown of the Kitimat, British Columbia smelter for fifteen weeks. Proportionately, shipments of semifabricated products continued to grow compared to the primary forms of aluminum, the former increasing to 55 per cent of Alcan's worldwide shipments in 1971 from 51 per cent the previous year. Alcan Aluminium Limited, a multinational company, has wholly and partly owned smelters in Norway, Japan, Australia, India, Spain, Brazil, Italy and Sweden. Construction of a new smelter at Lynemouth in Britain was delayed by building trades labour disputes but plant start-up was expected in the spring of 1972. Smelter facilities were expanded in Japan, India, Australia and Brazil. Primary aluminum production in 1971 by all of Alcan's subsidiaries and related companies totalled 1,865,000 tons, a 6 per cent gain compared with 1,752,000 tons in 1970, the increase being mainly from plants which serve national markets.

Canadian Reynolds Metals Company Limited produced 158,000 tons of aluminum at its smelter at

*All tons are short tons of 2,000 pounds.

Table 1. Canada, aluminum production and trade, 1970-71

	1970		1971*P*	
	(short tons)	($)	(short tons)	($)
Production	1,071,718		1,120,951	
Imports				
Bauxite ore				
Guyana	2,280,583	19,343,000	2,287,614	19,302,000
Surinam	174,418	3,288,000	329,159	4,990,000
United States	5,712	231,000	17,909	505,000
Sierra Leone	–	–	64,068	461,000
Other countries	323,116	2,009,000	16,371	105,000
Total	2,783,829	24,871,000	2,715,121	25,363,000
Alumina				
Jamaica	348,945	24,531,000	369,702	25,349,000
United States	385,479	27,385,000	303,638	20,935,000
Australia	182,578	12,868,000	285,664	19,751,000
Guyana	89,657	6,096,000	60,678	3,872,000
Other countries	33,166	2,156,000	492	167,000
Total	1,039,825	73,036,000	1,020,174	70,074,000
Aluminum and aluminum alloy scrap	5,732	1,683,000	6,414	1,340,000
Aluminum paste and aluminum powder	1,120	739,000	1,422	860,000
Pigs, ingots, shots, slabs, billets, blooms, and extruded wire bars	13,425	8,612,000	17,527	9,797,000
Castings	810	2,288,000	861	1,881,000
Forgings	898	2,879,000	965	2,318,000
Bars and rods, nes	756	908,000	4,126	2,640,000
Plates	12,306	8,335,000	13,730	8,563,000
Sheet and strip up to .025 inch thick	9,891	7,789,000	13,515	9,933,000
Sheet and strip, over .025 inch up to .051 inch thick	2,875	2,662,000	4,039	3,328,000
Sheet and strip, over .051 inch up to 1.25 inch thick	42,662	24,572,000	43,460	23,613,000
Sheet and strip over .125 inch thick	13,068	7,795,000	18,079	10,637,000
Foil or leaf	733	886,000	1,102	1,141,000
Converted aluminum foil	. .	2,374,000	. .	2,257,000
Structural shapes	2,198	5,372,000	2,856	5,783,000
Pipe and tubing	766	1,347,000	801	1,328,000
Wire and cable, excluding insulated	1,109	1,147,000	1,783	1,582,000
Aluminum and aluminum alloy fabricated materials, nes	. .	3,486,000	. .	6,484,000
Total aluminum imports		263,655,000		188,922,000
Exports				
Pigs, ingots, shot, slab, billets blooms and extruded wire bars				
United States	324,799	159,902,000	449,511	207,347,000
Britain	185,292	108,297,000	104,851	60,569,000
Japan	91,166	40,289,000	104,907	41,578,000
West Germany	33,932	16,221,000	33,588	16,832,000
Argentina	17,458	9,473,000	24,405	12,125,000
South Africa	44,765	25,414,000	18,960	10,063,000
Spain	8,519	4,903,000	21,314	9,342,000
Belgium and Luxembourg	18,638	10,390,000	13,762	7,500,000
Brazil	7,221	3,802,000	14,810	6,991,000
Turkey	5,963	3,293,000	13,060	6,425,000

Table 1 (Cont'd)

	1970		1971p	
	(short tons)	($)	(short tons)	($)
Exports (cont'd)				
India	1,515	788,000	10,942	5,239,000
France	10,015	5,688,000	8,881	4,616,000
Italy	14,674	7,634,000	7,963	3,826,000
Yugoslavia	6,168	3,256,000	5,807	3,074,000
New Zealand	13,099	7,310,000	5,259	3,002,000
Other countries	56,374	31,022,000	50,929	25,698,000
Total	839,598	437,682,000	888,949	424,227,000
Castings and forgings				
United States	2,677	4,131,000	3,575	4,423,000
France	1	24,000	14	83,000
West Germany	2	44,000	13	49,000
Barbados	–	–	10	9,000
Other countries	123	4,472,000	20	38,000
Total	2,803	273,000	3,632	4,602,000
Bars, rods, plates, sheet and circles				
United States	3,241	2,753,000	3,400	2,571,000
Portugal	559	321,000	3,889	2,182,000
New Zealand	2,919	1,747,000	3,365	1,955,000
Mexico	31	29,000	1,573	818,000
Jamaica	811	648,000	628	480,000
Algeria	881	558,000	879	461,000
South Africa	2,113	1,246,000	554	329,000
Panama	429	375,000	343	308,000
Netherlands	177	222,000	236	182,000
Other countries	1,428	1,299,000	1,188	957,000
Total	12,589	9,198,000	16,055	10,243,000
Foil				
United States	213	251,000	184	182,000
Mexico	22	37,000	10	17,000
Britain	2	3,000	2	3,000
West Germany	1	1,000	2	2,000
Other countries	20	22,000	2	2,000
Total	258	314,000	200	206,000
Fabricated materials, nes				
United States	3,724	3,628,000	4,112	3,815,000
Argentina	–	–	3,708	1,828,000
Pakistan	–	–	533	516,000
Britain	453	652,000	252	412,000
Colombia	13	17,000	434	308,000
Other countries	3,089	2,674,000	2,480	2,323,000
Total	7,279	6,971,000	11,519	9,202,000
Ores and concentrates				
United States	17,195	1,926,000	16,121	1,816,000
Italy	2,453	282,000	2,822	324,000
France	1,693	211,000	720	89,000
Spain	1,067	182,000	565	85,000
Britain	1,008	143,000	530	69,000
Norway	145	23,000	146	21,000
Other countries	216	32,000	286	46,000
Total	23,777	2,799,000	21,190	2,450,000

Table 1 (Cont'd)

	1970		1971p	
	(short tons)	($)	(short tons)	($)
Exports (cont'd)				
Scrap				
United States	32,974	11,232,000	37,147	12,522,000
Italy	9,180	3,859,000	5,553	1,896,000
Japan	171	48,000	2,260	533,000
Spain	673	133,000	1,478	316,000
West Germany	2,263	873,000	639	169,000
Other countries	1,051	424,000	1,137	311,000
Total	46,312	16,569,000	48,214	15,747,000
Total aluminum exports		478,005,000		466,677,000

Source: Statistics Canada.
pPreliminary; – Nil; nes Not elsewhere specified; . . Not available.

Table 2. Canada, primary aluminum production, trade and consumption, 1962-71

	Production	Imports	Exports	Consumption[1]
	(short tons)			
1962	690,297	3,855	576,206	151,898
1963	719,390	1,954	635,187	161,833
1964	842,640	3,996	627,992	172,443
1965	830,505	6,945	707,512	213,094
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	1,078,717r	11,531	886,688	269,027
1970	1,071,718	13,425	839,598	275,743
1971p	1,120,951	17,527	888,949	. .

Source: Statistics Canada.
[1]Including secondary as reported by consumers.
pPreliminary; rRevised; . . Not available.

Baie-Comeau, Quebec, practically the same as its 1970 production.

Noranda Aluminum Inc. is a wholly owned subsidiary of Noranda Mines Limited of Toronto. All of the subsidiary company's operations are located in the United States. Construction of a 70,000-ton-a-year smelter at New Madrid, Missouri was completed in September and production of primary aluminum was 37,000 tons in 1971.

The geographical locations of Canadian smelters in relation to ore supply are shown on the accompanying map. Alcan produces alumina at Arvida, Quebec, the only alumina-producing facility in Canada. It has a capacity of 1,335,000 tons a year. Of the company's total 1971 alumina output of 3.1 million tons, 40 per cent was produced at this plant mainly to meet the requirements of Alcan's four smelters in Quebec. For many years bauxite for this plant was supplied by Guyana. However, on July 15, 1971, the assets of Alcan's subsidiary, The Demerara Bauxite Company, were taken over by the Guyanian Government. Alcan has contracted to purchase sizable quantities of Guyana bauxite in 1972 and 1973, but considerably less than its previous supplies. It is anticipated that imports of bauxite from Guyana will decrease markedly, being displaced by bauxite from Alcan's project in Guinea, beginning in 1973, and from Brazil in later years. In the meantime, requirements are being purchased from Surinam, Sierra Leone, Malaysia, Ghana and other sources.

Alumina, mainly from Jamaica and Australia, is imported to supply Alcan's Kitimat plant, and its Quebec smelters to a minor extent. The Baie-Comeau smelter of Canadian Reynolds purchases alumina from the parent company's plant in Corpus Christi, Texas.

Consumption. Canadian consumption of aluminum at the first processing stage is shown in Table 3. Primary aluminum consumption increased from 245,700 tons in 1970 to an estimated 281,000 tons in 1971, a substantial gain of 14 per cent, due largely to growth in housing construction.

World industry

World production of bauxite in 1971 was 66.1 million tons. The noncommunist countries mined 57.7 million tons, an increase of 15 per cent over 1970. Jamaica continued as the leading bauxite producer in 1971, mining 13.8 million tons, closely followed by Australia with 12.3 million tons.

Although bauxite mining was affected by some cutbacks in aluminum output to ease oversupply,

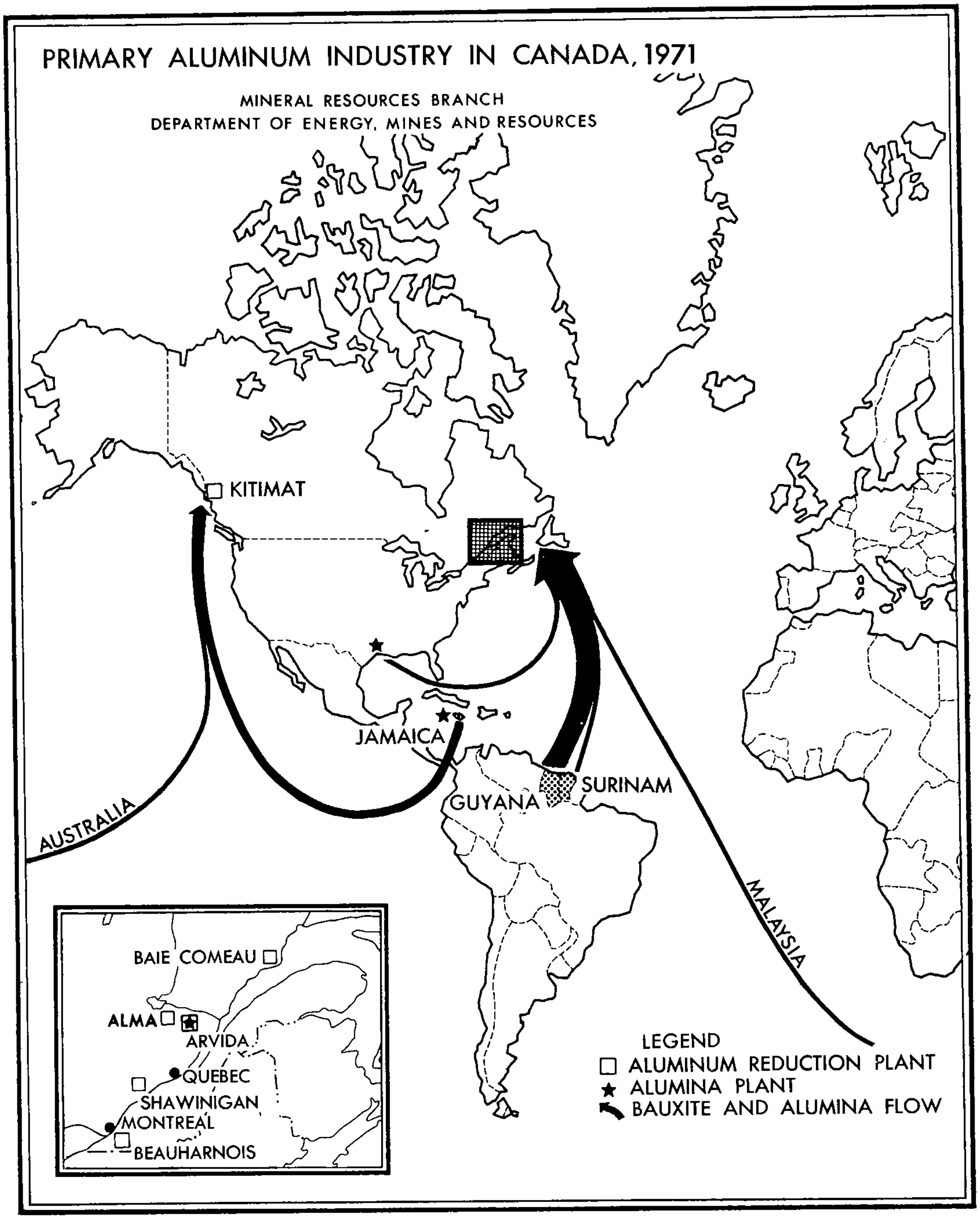

PRIMARY ALUMINUM INDUSTRY IN CANADA, 1971
MINERAL RESOURCES BRANCH
DEPARTMENT OF ENERGY, MINES AND RESOURCES
KITIMAT
JAMAICA
GUYANA
SURINAM
AUSTRALIA
MALAYSIA
BAIE COMEAU
ALMA
ARVIDA
QUEBEC
SHAWINIGAN
MONTREAL
BEAUHARNOIS
LEGEND
ALUMINUM REDUCTION PLANT
ALUMINA PLANT
BAUXITE AND ALUMINA FLOW

Table 3. Canada, consumption of aluminum at first processing stage

	1968	1969	1970	1971^p
	(short tons)			
Castings				
Sand	1,614	1,578	1,596	..
Permanent-mould	12,325	12,262	11,574	..
Die	19,747	22,670	19,546	..
Other	92	103	73	..
Total	33,778	36,613	32,789	..
Wrought products				
Extrusions, including tubing	61,260	69,653	64,145	..
Sheet, plate, coil and other (including rod, forgings and slugs)	135,960	151,508	168,521	..
Total	197,220	221,161	232,666	..
Destructive uses				
Non-aluminum-base alloys, powder and paste, deoxidizers and other	11,392	11,253	10,288	..
Total consumed	242,390	269,027	275,743	..
Secondary aluminum consumed	35,265	34,787	30,035	..

Receipts and Inventories at Plants	Metal Entering Plants		On Hand Dec. 31	
	1970	1971^p	1970	1971^p
Primary aluminum ingot and alloys	242,930	..	56,211	..
Secondary aluminum	20,613	..	1,834	..
Scrap originating outside plant	35,925	..	4,950	..

Source: Statistics Canada.
^{p}Preliminary; .. Not available.

Table 4. World primary aluminum production and consumption, 1971

	Production	Consumption
	(thousand short tons)	
Canada	1,121	281
United States	3,924	4,316
Europe	2,481	2,660
Japan	978	1,042
Australia	240	152
India	196	213
Africa	210	85
Subtotal (includes countries not listed)	9,513	9,235
Communist countries	2,630	2,469
Total	12,143	11,704

Sources: OECD for member countries; remainder from World Bureau of Metal Statistics and other sources.

development of additional mining facilities continued in preparation for an anticipated resumption of the historical growth of aluminum consumption. Much of this bauxite activity is taking place in Australia. The largest single bauxite mine in the world at Weipa, in Queensland, is being expanded to an annual capacity of 10,500,000 tons by Comalco Limited. At Gove in the Northern Territory, Nabalco Pty shipped its first bauxite to Japan and expects that an output of 2,000,000 tons a year will be attained within two years. Development of a mine at Kimberley, Western Australia is planned; the scheduled operating rate is up to 2,500,000 tons of bauxite a year. This facility will be owned by a consortium of American Metal Climax, Inc., holding the largest single interest, as well as Japanese and Dutch companies. In Guinea the Boke deposit is being developed by the Guinean Government and a group of six aluminum producers, of which the Aluminum Company of America (Alcoa), Alcan, and Martin Marietta Aluminum Inc. are the major shareholders. It is scheduled to produce 4,500,000

Table 5. Canadian aluminum smelter capacity, 1971

Smelter Location	Annual Capacity
	(short tons)
Aluminum Company of Canada, Limited	
Quebec	
Arvida	458,500
Beauharnois	51,500
Shawinigan	95,000
Isle-Maligne	130,000
British Columbia	
Kitimat	300,000
Total Alcan capacity	1,035,000
Canadian Reynolds Metals Company, Limited	
Quebec	
Baie-Comeau	175,000
Total Canadian capacity	1,210,000

tons a year of bauxite in 1973 and 9,000,000 tons a year by 1979. The first bauxite was shipped from Vanau Levu, in the Fiji Islands, by Bauxite Fiji Limited, whose shareholders are Nippon Light Metal Co., Sumitomo Chemical Co. and Showa Denko K.K. This deposit will have an output of about 275,000 tons a year. The Indonesian state-owned Aneka Tambang Mining Company also expanded its bauxite production. Other projects in various stages of development during 1971 are in Surinam, where the Government and Reynolds Metals Company are investigating a new bauxite mining operation of about 400,000 tons a year, in the British Solomon Islands, Greece, Hungary, Ghana and Brazil.

The minimum permissable alumina content of metal-grade bauxite is around 40 per cent with a maximum silica content of 5 per cent. Iron oxide (Fe_2O_3) and titania (TiO_2) are found in varying amounts in practically all bauxites but are harmless except that they increase the quantity of waste matter to be handled. The preference is for bauxite in which the alumina content is in the form of the mineral gibbsite, $Al_2O_3 \cdot 3H_2O$, the trihydrate, which is less costly to process to alumina. Boehmite, AlO (OH), and diaspore, $HAlO_2$, are the other low-silica minerals of commercial interest, but the extraction of alumina from these ores requires stronger caustic solutions as well as higher temperatures and pressures. In some countries which are deficient in bauxite, alternative raw material sources of aluminum are being investigated and some are being utilized. Alunite is being developed as a possible source of alumina near Cedar City, Utah and a pilot processing plant is planned. Russia has utilized both alunite and nepheline syenite to produce alumina. Mexico is building a plant of 3,300 tons a year initial capacity to produce alumina from alunite, using a process developed by its University of Guanajuato. Fertilizer and other byproducts are produced from these various processes, but whether they can compete economically with a large-scale, conventional Bayer plant is questionable.

No up-to-date statistics are available on the production of alumina, the intermediate product between bauxite and aluminum, but presumably production paralleled the trends in aluminum in 1971. In spite of an oversupply of aluminum, expansion of alumina facilities continues. Recent trends are to locate alumina plants near the source of bauxite supply. This appears a logical step for bauxite-supplying countries in their efforts to export a more valuable commodity, thereby increasing employment, tax revenue and foreign exchange. Thus in Australia the Queensland Alumina Limited plant at Gladstone, owned by Kaiser Aluminum & Chemical Corporation, Compagnie Pechiney S.A., Alcan, Comalco, and Conzinc Riotinto of Australia Limited, increased its annual production to 1,400,000 tons in 1971, with a third expansion to 2,200,000 tons scheduled for 1973. The Gove project, mentioned previously, includes plans for an alumina refinery located nearby of 1,100,000 tons annual capacity. Elsewhere in Australia, Alcoa is building a second refinery in Western Australia at Pinjarra and Comalco is planning an alumina refinery near its Weipa bauxite deposit. In Jamaica, Revere Copper and Brass Inc. recently completed its alumina facility of 220,000 tons annual capacity. However, not all new alumina facilities are located in bauxite-producing countries. Nippon Light Metal is completing a new plant in Japan and Alcoa added to its alumina facilities at Point Comfort, Texas. A 660,000 ton-a-year alumina refinery is under construction in Sardinia which will be supplied with Australian bauxite. The partners in this project are Alsar S.p.A., Montecatini S.p.A., Comalco,

Table 6. Estimated world production of bauxite in 1971

	Production
	(million short tons)
Jamaica	13.8
Australia	12.3
Surinam	6.2
Guyana	3.9
France	3.3
Guinea	3.1
Greece	2.8
United States	2.2
Other noncommunist countries[1]	10.1
Total noncommunist countries	57.7
Communist countries	8.4
World total	66.1

Source: United States Bureau of Mines, Division of Nonferrous Metals.

[1] Production of Yugoslavia included in noncommunist countries.

and Metallgesellschaft, A.G. As for future projects, Reynolds plans to build an alumina plant in Surinam in conjunction with a new bauxite mine. Martin Marietta Aluminum (Formerly Harvey Aluminum Incorporated) is adding to its Virgin Islands plant. Additional alumina facilities are planned in Indonesia, West Germany, India, Hungary, Japan, Ghana, Yugoslavia and Greece.

Primary aluminum production throughout the world was 12,143,000 tons in 1971, an increase of 6.7 per cent from the total in 1970, although in some quarters plants operated at well under capacity. Much of this increase took place in Japan (22%) and Europe (14%), whereas the outputs of Canada and the United States were little changed. Canada, with a production of 1.1 million tons, maintained its third place ranking among world producers, after the United States and U.S.S.R.

In spite of overcapacity in existing primary aluminum facilities, extensive additions occured in 1971, particularly in the United States, West Germany, Japan, and Britain, the culmination of aggressive expansion plans initiated about three years previously. Although some efforts were made to defer planned expansion, no less than thirteen new smelters began operations in 1971, and augmented by capacity increases in several existing plants, total capacity in the noncommunist world was approximately 16 per cent more than in the previous year. An estimate of the major increases to primary aluminum capacity which started up in 1971 is set forth in Table 7. In the near future sizable additions to primary aluminum capacity are anticipated in the United States, Great Britain, West Germany, Yugoslavia and New Zealand.

The world's traditional major exporters, Canada and Norway, continue to experience intense competition from the growing output of relatively new producing countries, among them, Ghana, Greece, Surinam, Cameroon, Australia, New Zealand, The Netherlands, Iceland and Bahrain. At the same time, some large importing countries, including the United States, Japan, Britain and West Germany, have increased their domestic primary aluminum capacity, with effects on trade patterns as yet undetermined.

Table 7. Estimated increases in primary aluminum capacity in 1971

	Company	Location	New Plant (N) or Addition (A)	Capacity Increase
				(short tons)
United States	Martin Marietta Aluminum (formerly Harvey Aluminum)	Goldendale, Wash.	N	100,000
	Noranda Aluminum Inc.	New Madrid, Mo.	N	70,000
	Gulf Coast Aluminum Corp.	Lake Charles, La.	N	35,000
Great Britain	British Aluminum Co.	Invergordon	N	110,000
West Germany	Leichtmetallgesellschaft GmbH (Metallgesellschaft & Alusuisse)	Essen	N	93,000
	Kaiser – Preussag AG	Düsseldorf	N	70,000
Japan	Mitsui Aluminum Co.	Okmuta	N	35,000
	Nippon Light Metal Co. (Alcan 50%)	Tomakamai	A	80,000
	Showa Denko K.K.	Chiba	A	55,000
Bahrain	Aluminium Bahrain	Alba	N	130,000
Norway	Mosal A/S (Elkem A/S & Alcoa)	Lista	N	55,000
	Alnor Aluminium (Martin Marietta & Norsk Hydro)	Karmoy	A	25,000
	Aardal ogg Sunndal Verk (Alcan & Norwegian Gov't)	Aardal	A	45,000
New Zealand	New Zealand Aluminium Smelter Ltd. (Comalco, Showa Denko & Sumitomo)	Bluff	N	80,000
Netherlands	Pechiney Nederland NV	Vlissingen	N	95,000
Union of South Africa	Alusaf (Pty) Ltd. (Alusuisse & others)	Richards Bay	N	55,000
Australia	Comalco Limited	Bell Bay	A	25,000
	Alcan Australia Ltd.	Kurri Kurri	A	10,000
India	Indian Aluminium Co.	Belgaum	A	15,000
Brazil	Alumina Minas Gerais (Alcan)	Aratu	N	11,000

Canada exported a greater volume of aluminum in 1971 than in 1970, although the value dropped because of severe price competition. The United States continued to be the largest single market for Canadian aluminum in 1971. Exports to this market totalled 514,000 tons, mainly in the primary forms of ingots and pigs, representing a 34 per cent increase over 1970.

World primary aluminum consumption in 1971 exhibited a mixed trend with a total gain of 8 per cent in the noncommunist world. Both the United States and Canada had sizable gains over 1970, 12 per cent and 14 per cent, respectively. On the other hand, consumption in Europe decreased by about one per cent. Japanese consumption gained only 7 per cent, much less than in previous years. Noncommunist production outstripped consumption by some 275,000 tons, yet this situation was more favourable than in 1970 when there were about 400,000 tons of excess production. Nevertheless, the 1971 excess was a further addition to the extensive stockpile of surplus primary aluminum which has accumulated in various parts of the world. This surplus, overhanging world markets, undoubtedly was an important factor in reducing prices.

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 individual market, the Aluminum Association reports that the construction field was again the largest consumer in 1971, accounting for 27 per cent of shipments. Transportation, another major user, was in second place with 17 per cent, followed by container packaging 15 per cent, electrical uses 14 per cent, consumer durables 9 per cent and machinery and equipment 6 per cent.

The North American construction revival in 1971, particularly in housing, was responsible for the construction sector being aluminum's fastest growing user. Aluminum siding is being produced in an ever-increasing number of shapes and finishes. One of the most promising new markets is in factory-built, modular homes, where in addition to the usual large complement of aluminum siding, windows and doors, aluminum framing is now gaining acceptance. In the transportation sector, truck, recreational vehicle and rail car bodies are important consumers. But these users are much overshadowed by the automotive industry where an important breakthrough occurred in the aluminum engine block of the Chevrolet Vega model. Automotive trim produced from aluminum metallurgically bonded to stainless steel, which combines both an attractive finish and galvanic corrosion protection, shows promise as a new use. The all-aluminum can and easy-opening can ends are growing applications in the packaging field. The mass feeding concept in the food packaging industry portends a steadily rising use of foil. The rapidly growing air conditioning industry is also an important consumer.

Prices

The published price of 99.5 per cent aluminum ingot remained unchanged throughout 1971 at 29.5¢ a pound in Canada and 29¢ a pound in the United States. However, because of oversupply, substantial discounts below these prices were granted to purchasers on a contract basis.

Tariffs

Canada

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

United States

Item No.		On and After January 1 1971	1972
601.06	Bauxite	10¢ per lt*	free
		(¢ per lb)	
417.12	Aluminum compounds: hydroxide and oxide (alumina)	0.15*	0.12*
618.01	Unwrought aluminum, in coils, uniform cross section not greater than 0.375 inch	1.5	1.2
618.02	Unwrought aluminum, other, excluding alloys	1	1
618.04 618.06	Unwrought aluminum alloys, aluminum silicon and other aluminum alloys	1	1
618.10	Aluminum scrap (duty on scrap suspended until 30 June 1972)	0.9	0.7
	Various tariffs are in effect on more advanced fabricated forms of aluminum		

Sources: The Custom Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa. Tariff Schedules of the United States, Annotated (1972) TC Publication 452.
*Declared free as of July 16, 1971 by Public Law 92-151.

Antimony

M. GAUVIN

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 high-purity antimony metal. The antimony content of primary antimonial lead produced in 1971 was 330,000 pounds compared with 726,474 pounds in 1970.

Canadian requirements of antimony metal, antimony oxide and antimony salts are imported. Regulus (metal) import statistics were discontinued in 1964 but in earlier years the main suppliers were the People's Republic of China and Yugoslavia, which mine and refine antimony ores, and western European countries, which import antimony ores and concentrates and export refined metal and salts. Imports of antimony oxide in 1971 totalled 590,600 pounds, of which 72 per cent came from Britain, 14 per cent from the United States, 13 per cent from the People's Republic of China and the remainder from Belgium and Luxembourg.

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 the customers' requirements. The only other primary producer of antimonial lead is the Smelting Division, Brunswick Mining and Smelting Corporation Limited (formerly East Coast Smelting and Chemical Company Limited), which operates a smelter at Belledune, New Brunswick.

Secondary smelters recovered antimonial lead from scrap metal but no recent information is available concerning this production. In 1969 these smelters reclaimed 30,685 tons of antimonial lead from scrap compared with 26,815 tons in 1968.

Domestic sources and occurrences

The source of most of the antimonial lead produced at Trail is as 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 1 per cent antimony, which is recovered in anode residues from the electrolytic refining of the 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 plant produced an unspecified amount of antimonial dross in 1971; it produced 14 tons in 1970.

Several Canadian occurrences or deposits of the principal antimony mineral, stibnite (Sb_2S_3) have been explored and partly developed, but results generally have not been encouraging. The better known occurrences are in the Atlantic provinces, Quebec, British Columbia and the Yukon Territory. In

Table 1. Canada, antimony production, imports and consumption, 1970-71

	1970		1971p	
	(pounds)	($)	(pounds)	($)
Production				
Antimony content of antimonial lead alloys	726,474	1,104,040	330,000	249,000
Imports				
Antimony oxide				
Britain	731,500	734,000	428,000	332,000
United States	113,000	104,000	79,000	63,000
People's Republic of China	–	–	77,600	39,000
Belgium & Luxembourg	–	–	6,000	3,000
Total imports	844,500	838,000	590,600	437,000
Consumption				
Antimony regulus (metal) in production of:				
Antimonial lead alloys	788,747		. .	
Babbitt	124,451		. .	
Solder	30,272		. .	
Type metal	84,158		. .	
Other commodities[1]	114,381		. .	
Total	1,142,009		. .	

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

Table 2. Antimony, Canadian production, imports and consumption, 1962-71

	Production[1] (all forms)	Imports (regulus)	Consumption[2] (regulus)
	(lb)	(lb)	(lb)
1962	1,931,397	1,275,917	1,211,000
1963	1,601,253	1,036,235	976,000
1964	1,591,523	. .	558,000
1965	1,301,787	. .	660,000
1966	1,405,681	. .	1,098,000
1967	1,267,686	. .	1,190,000
1968	1,159,960	. .	1,169,000
1969	820,122	. .	1,306,000
1970	726,474	. .	1,142,000
1971p	330,000	. .	. .

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.
pPreliminary; . . Not available.

1965 proven and probable reserves of Yukon Antimony Corporation Ltd. were reported to be 100,000 and 250,000 tons, respectively, averaging 5 per cent antimony. These deposits are on Carbon and Chieftain hills in the Wheaton River district of the Yukon Territory, about 55 miles southwest of Whitehorse. During 1971 Consolidated Durham Mines & Resources Limited worked to bring into production its Lake George area antimony property near Fredericton, New Brunswick. During the year, a concentrator with a capacity of 400 tons of ore a day was constructed and at year-end was being tested and tuned up for production. Extensive diamond drilling of this old deposit indicated more than 100,000 tons averaging 7 per cent antimony in a section of the known veins. The company expects that underground development work will increase these reserves.

World review

World mine production of antimony in 1971, as estimated by the United States Bureau of Mines, totalled 76,630 tons, 3,500 tons more than world production in 1970. Antimony is produced from ores

Table 3. Canadian consumption of antimonial lead alloy,[1] 1969-71

	1969	1970	1971^p
	(lb)	(lb)	
Batteries	2,155,677	1,283,478	
Type metal	105,019	16,421	. .
Babbitt	14,111	66,125	
Solder	3,818	9,348	
Other uses	43,145	25,030	. .
Total	2,321,770	1,400,402	. .

Source: Statistics Canada.
[1]Antimony content of primary and secondary antimonial lead alloys.
^{p}Preliminary; . . Not available.

Table 4. Canadian consumption of antimonial lead alloy,[1] 1962-71

	(pounds)
1962	2,662,400
1963	2,688,157
1964	2,506,454
1965	2,775,241
1966	2,593,733
1967	2,496,032
1968	2,124,903
1969	2,321,770
1970	1,400,402
1971^p	. .

Source: Statistics Canada.
[1]Antimony content of primary and secondary antimonial lead alloys.
^{p}Preliminary; . . Not available.

and as a smelter byproduct in about 25 countries with the major sources of ore being the Republic of South Africa, the People's Republic of China, Bolivia, U.S.S.R., Mexico, Turkey and Yugoslavia. The world's reportedly richest antimony mine, the underground Gravelotte, is in the Republic of South Africa. NL Industries, Inc. (formerly National Lead Company) operates the world's largest antimony smelter for ores and concentrates at Laredo, Texas, where it produces antimony metal and oxide, mainly from imported Mexican antimony ores. Recovery of antimony in the treatment of antimonial lead scrap is a major source of supply. This secondary supply represents a substantial portion, up to 55 per cent, of total antimony supply in the United States and other highly industrialized countries.

The severe decline in the price of antimony ore, metal and oxides that began in the first quarter of 1970 continued at a more gradual rate in the first and second quarters of 1971. Prices thereafter levelled off and remained steady for the balance of the year and

Table 5. World mine production of antimony, 1969-71

	1969	1970^p	1971^e
	(st)	(st)	(st)
Republic of South Africa	20,080	18,841	20,000
Bolivia	14,484	12,724	13,700
People's Republic of China	13,000	13,000	*
U.S.S.R.	7,300	7,400	*
Mexico	3,557	4,925	5,400
Turkey	3,495	3,053	*
Yugoslavia	2,278	2,200	2,300
Morocco	1,551	2,175	*
Italy	1,272	1,381	*
United States	938	1,130	1,130
Australia	933	833	*
Thailand	827	2,598	*
Czechoslovakia	660	660	*
Canada	410	363	165
Other countries	2,259	1,924	33,935
Total	73,044	73,207	76,630

Sources: For Canada, Statistics Canada. U.S. Bureau of Mines *Minerals Yearbook*, Preprint 1970 for 1969 and 1970; U.S. Bureau of Mines Commodity Data Summaries January 1971, for 1971.
*Included in "Other countries".
^{p}Preliminary; ^{e}Estimated.

into 1972. There are many applications in which other metals substitute satisfactorily for antimony. With the high prices in 1969 many lead-acid battery manufacturers began to reduce the antimony contained in battery lead alloys. The antimony content of battery alloys is now down to not much more than 4 per cent whereas the content has recently been as high as 11 per cent.

World production of antimony, which rose sharply in 1969 because of the high prices, continued at the same rate in 1970 and a small increase in production is estimated for 1971. Other metals were being substituted for antimony and while world consumption figures are not available, United States industrial consumption of primary antimony continued to decline. This increased world supply of antimony and slackening demand caused several price decreases in 1971. Mine production is closely aligned with price and the recent downtrend has discouraged development of antimony resources.

The United States in 1971 was again the noncommunist world's largest consumer of antimony and continued to depend on foreign supplies for much of its requirements. Its consumer requirements in 1970 were about 25 per cent of noncommunist primary world supply, in addition to what it could secure from its scrap reclamation. However, as a result of the much higher prices of 1969 and 1970, substitution of other materials for antimony was continued mainly in pigment, plastic, rubber and battery manufacture. The technology and opportunity for substitution are fairly well understood; however, over the long term the availability and cost of the competing metals will strongly influence the antimony requirement and use pattern. This applies particularly to potential substitutes such as copper, calcium, mercury, titanium, lead, zinc, chromium, zirconium, bismuth and various organic synthetics. Antimony metal contained in the United States Government stockpile for conventional war requirements totalled 46,746 tons as of June 30, 1971, unchanged from that at the beginning of the year.

Outlook

The world outlook for antimony appears to be favourable with a steady demand expected to prevail during the next few years. The major end use of antimony is expected to continue to be as antimonial lead for storage batteries. As less developed countries become more industrialized and mechanized this use is expected to grow. The growing use as a flame retardant should offset any decline in some of the metal's historic use or its substitution by other metals.

For the near future, prices are expected to remain stable in terms of constant dollars. The availability of antimony from the major producers, the Republic of South Africa, Bolivia and the People's Republic of China and also from the United States Government stockpile will control short-term fluctuations and in the longer term will provide adequate supplies of antimony. Consumption of primary antimony increased substantially towards the end of 1971 while industrial stocks declined.

Uses

The principal use of antimony is 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, containing from 3 to 12 per cent antimony, in storage batteries remains the major outlet for antimony. Antimony 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.

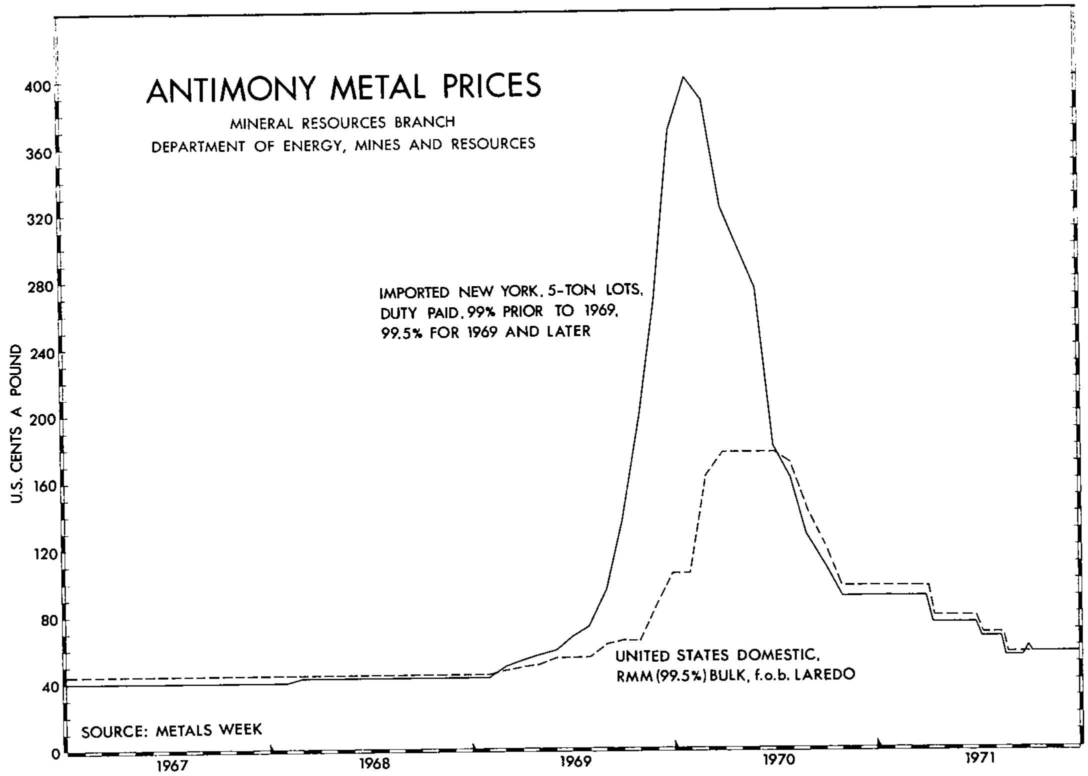
Antimony oxide Sb_2O_3 usually produced directly from high-grade sulphide ore, is used extensively in plastics and in flameproofing compounds. Demand for this use is increasing rapidly. Because of its high hiding power it is valuable for paint formulation and various chemical compounds produce a wide range of pigments. The trioxide is also a glass former and is sought for its ability to impart hardness and acid resistance to enamel coverings for such items as bathtubs, sinks, bowls and refrigerators. Mixed with chlorinated paraffin and lime it is used as a finishing additive to textiles. The pentasulphide Sb_2S_5 is employed as a vulcanizing agent by the rubber industry and burning antimony sulphide creates a dense white smoke that is used in visual control, in sea markers and in visual signaling.

High-purity metal is used by manufacturers of indium-antimony and aluminum-antimony inter-

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

Product	1969	1970	1971
	(short tons, antimony content)		
Metal products			
Ammunition	115	102	*
Antimonial lead	6,723	5,246	5,336
Bearing metal and bearings	758	481	447
Cable covering	55	38	17
Castings	33	16	12
Collapsible tubes and foil	56	35	22
Sheet and pipe	105	77	71
Solder	242	286	132
Type metal	541	220	146
Other	137	73	102
Total	8,765	6,574	6,285
Nonmetal products			
Ammunition primers	37	27	22
Fireworks	30	17	*
Flameproofing chemicals and compounds	2,096	1,710	1,000
Ceramics and glass	2,108	1,820	1,506
Matches	–	–	–
Pigments	722	610	405
Plastics	2,558	1,667	863
Rubber products	433	519	276
Other	1,094	993	671
Total	9,078	7,363	4,743
Grand total	17,843	13,937	11,028

Source: United States Bureau of Mines, *Minerals Yearbook* Preprint 1970, and Mineral Industry Surveys.
*Included with "Other" to avoid disclosing individual company confidential data.



metallic compounds as a semiconductor in transistors and rectifiers.

Prices

Antimony prices throughout the world started to decline in early 1970 which continued in 1971 and levelled off in mid-1971. The United States domestic price of antimony as quoted in *Metals Week*, in bulk 99.5 per cent, fob Laredo, Texas was 96 cents a pound at the beginning of 1971 and remained there until March when it dropped to 68 cents. A further reduction in July brought the price down to 57 cents, which was still in effect at year-end.

The United States price of imported antimony metal, as quoted in *Metals Week,* in 5-ton lots, 99.5-99.6 per cent, fob New York, duty paid, was 90 cents a pound at the beginning of 1971. This price dropped three times in the first half of the year bringing it down to 56 cents in July. It rose slightly to 57 cents in September, where it remained at year-end.

Tariffs

Canada

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

United States

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

Sources: The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa. Tariff Schedules of the United States, annotated (1972), TC Publication 452.

Asbestos

M.A. BOUCHER

Canadian production (shipments) of asbestos fibre was 1,641,000 tons valued at $210.4 million in 1971 compared with 1,661,644 tons valued at $208.1 million in 1970. All the Canadian production consists of chrysotile and 81 per cent of it comes from the Eastern Townships of Quebec, 6 per cent from the Yukon, over 5 per cent from British Columbia, nearly 5 per cent from Newfoundland and 3 per cent from Ontario.

Exports of fibre represent 95 per cent of production leaving 5 per cent for Canadian consumption. The United States continued as our major market absorbing 40 per cent of total asbestos fibre production. The major changes in trading during the year were with the United States and Japan: in 1971 fibre exports to the United States increased by 49,181 tons while exports to Japan decreased by 59,004 tons. Total Canadian exports were valued at $229,665,000 of which $5,740,000 was in manufactured products. Imports were valued at $15,801,000 of which $14,507,000 was in manufactured products. Brake linings and asbestos cement building materials account for the majority of these imports.

Canadian developments

Canadian producers, foreseeing greater markets for asbestos, spent over $200 million on new projects during 1971, either to develop new ore or to expand production facilities.

Producers. In Quebec expansion was continuing at the Canadian Johns-Manville Company, Limited, Jeffrey mine and mill, to increase production by approximately 100,000 tons of fibre a year by 1974. About one third of the increased production will consist of grade 6D fibre recovered from pre-1930 tailings. The project, once completed, will ensure continued production at a minimum of 600,000 tons of fibre a year.

Asbestos Corporation Limited completed expansion of facilities at King Beaver mine, increasing capacity from 8,000 to 12,400 tons of ore a day. Development of the deep-lying Penhale orebody adjacent to the Normandie mine was continuing. Production by underground mining was scheduled, at 8,200 tons of ore a day, early in 1972. The Penhale orebody will eventually replace the Normandie mine. By mid-1972, Asbestos Corporation expects to start production at its Asbestos Hill mine in Ungava. The mine will produce about 300,000 tons of concentrate a year, which will be shipped to Nordenham, West Germany, where it will be refined and reduced to 100,000 tons of standard-grade fibre, mostly of groups 4 and 5.

Bell Asbestos Mines, Ltd. has been working on a long-range modernization program which may also see productive capacity increase. In the vicinity of the open pit, a production shaft has been sunk to a depth of 1,450 feet; underground work proceeded from the shaft with a view to large-scale underground mining.

At Lake Asbestos of Quebec, Ltd. milling refinements were being made and capacity increased from 6,000 to 9,000 tons of ore a day.

Flintkote Mines Limited closed its operations on December 31, 1971.

In Ontario production from the mine of Hedman Mines Limited and from Johns-Manville Mining and Trading Limited's Reeves mine showed a modest increase in 1971. The Hedman mine has not yet reached full production capacity.

Advocate Mines Limited, Newfoundland's only asbestos producer increased its production by about 15 per cent in 1971 compared with the previous year.

In British Columbia, Cassiar Asbestos Corporation Limited, Cassiar, completed construction of the mill expansion which started in 1970. The expansion increased production capacity from 80,000 to

Table 1. Canada, asbestos production and trade, 1970-71

	1970		1971^p	
	(short tons)	($)	(short tons)	($)
Production (shipments)				
By type				
Crude, group 1, 2 and other milled	7,252	3,599,224	..	..
Group 3, spinning	31,836	12,419,236	..	..
Group 4, shingle	446,584	88,433,576	..	..
Group 5, paper	258,617	39,209,706	..	..
Group 6, stucco	341,783	35,442,621	..	..
Group 7, refuse	570,770	28,552,431	..	..
Group 8, sand	4,802	489,739	..	..
Total	1,661,644	208,146,533[1]	1,641,000	210,435,000
By province				
Quebec	1,367,524	161,583,510	1,333,000	158,595,000
British Columbia	86,730	16,033,827	88,000	18,500,000
Newfoundland	62,727	11,669,402	77,000	14,000,000
Yukon	105,638	13,927,652	99,000	13,900,000
Ontario	39,025	4,932,142	44,000	5,440,000
Total	1,661,644	208,146,533[1]	1,641,000	210,435,000[1]
Exports				
Crude				
United States	6	3,000	45	44,000
Japan	73	58,000	49	40,000
Italy	8	14,000	9	16,000
West Germany	12	13,000	10	10,000
Other Countries	2	3,000	2	3,000
Total	101	91,000	115	113,000
Milled fibre (group 3, 4 and 5)				
United States	206,706	44,587,000	207,954	45,723,000
Britain	60,405	14,393,000	61,508	14,252,000
West Germany	60,164	13,023,000	56,033	12,177,000
Japan	57,529	10,253,000	35,086	6,607,000
India	21,756	4,732,000	17,198	4,035,000
France	49,622	10,565,000	51,229	10,989,000
Italy	16,352	3,537,000	13,042	2,912,000
Mexico	25,628	5,629,000	22,174	4,955,000
Czechoslovakia	1,045	341,000	3,867	957,000
Algeria	590	128,000	1,977	485,000
Belgium and Luxembourg	26,236	5,738,000	27,872	6,246,000
Netherlands	21,386	4,578,000	15,530	3,510,000
Other countries	276,905	54,346,000	256,665	52,084,000
Total	824,324	171,850,000	770,135	164,932,000
Shorts (group 6,7,8,9,)				
United States	407,585	27,379,000	455,479	31,045,000
Japan	110,390	10,363,000	73,853	6,863,000
Britain	39,727	2,498,000	45,457	3,057,000
South Korea	13,470	1,486,000	21,645	2,314,000
West Germany	28,754	2,293,000	31,692	2,183,000
Australia	15,672	1,076,000	20,889	1,816,000
Belgium and Luxembourg	14,191	1,232,000	16,627	1,385,000
France	21,793	1,481,000	22,673	1,359,000
Spain	8,617	829,000	10,806	1,144,000
Netherlands	10,813	610,000	11,751	844,000
Denmark	3,586	391,000	7,155	827,000
Other countries	63,409	5,669,000	67,286	6,043,000
Total	738,007	55,307,000	785,313	58,880,000
Grand total, crude, milled fibres and shorts	1,562,432	227,248,000	1,555,563	223,925,000

Table 1 (cont'd)

	1970	1971p
	($)	($)
Manufactured products		
Brake linings and clutch facings		
United States	798,000	552,000
Cuba	576,000	119,000
Guatemala	65,000	61,000
Lebanon	57,000	51,000
Ecuador	109,000	48,000
Syria	7,000	21,000
Thailand	3,000	12,000
Greece	18,000	11,000
Other countries	158,000	82,000
Total	1,791,000	957,000
Asbestos and asbestos cement building materials		
United States	2,236,000	1,614,000
Netherlands	56,000	210,000
Australia	125,000	170,000
South Africa	26,000	70,000
Algeria	121,000	51,000
Japan	98,000	51,000
Dominican Republic	–	43,000
Venezuela	29,000	24,000
Other countries	526,000	110,000
Total	3,217,000	2,343,000
Asbestos basic products, nes		
United States	1,130,000	2,174,000
Switzerland	25,000	90,000
Australia	2,000	28,000
France	1,000	25,000
Asbestos basic products, nes		
Netherlands	45,000	23,000
Finland	7,000	14,000
Thailand	1,000	9,000
Other countries	217,000	77,000
Total	1,428,000	2,440,000
Total exports, asbestos manufactured products	6,436,000	5,740,000
Imports		
Asbestos, unmanufactured	1,081,000	1,294,000
	5,833 st	6,599 st
Asbestos manufactured		
Cloth, dryer felts, sheets woven or felted	1,161,000	1,078,000
Packing	1,087,000	983,000
Brake linings	3,365,000	4,772,000
Clutch facings	434,000	363,000
Asbestos-cement		
Shingles and siding	233,000	258,000
Board and sheets	827,000	947,000
Asbestos and Asbestos-cement building materials, nes	1,575,000	3,656,000
Asbestos and asbestos-cement basic products nes	1,597,000	2,450,000
Total asbestos, manufactured	10,279,000	14,507,000
Total asbestos, unmanufactured and manufactured	11,360,000	15,801,000

Sources: Statistics Canada.
[1] Does not include value of containers.
p Preliminary; – Nil; nes Not elsewhere specified.

120,000 tons of fibre a year. Included in the new production will be 10,000 tons a year of grade AZ, equivalent to group 6 fibre in Quebec.

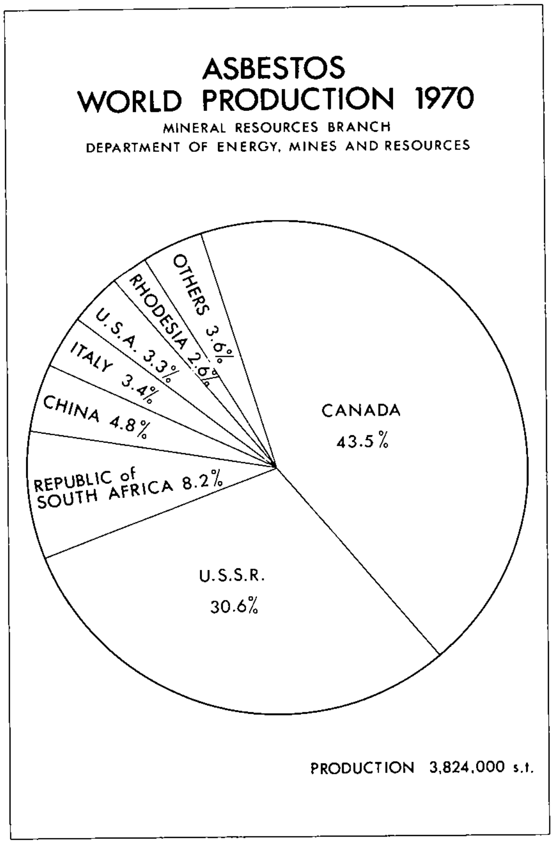
At its Clinton Creek mine in the Yukon Territory, Cassiar Asbestos Corporation Limited intends to increase production from 100,000 to 120,000 tons of fibre annually by making only relatively minor additions to its operations. A new CZ grade will be introduced to the market during 1972.

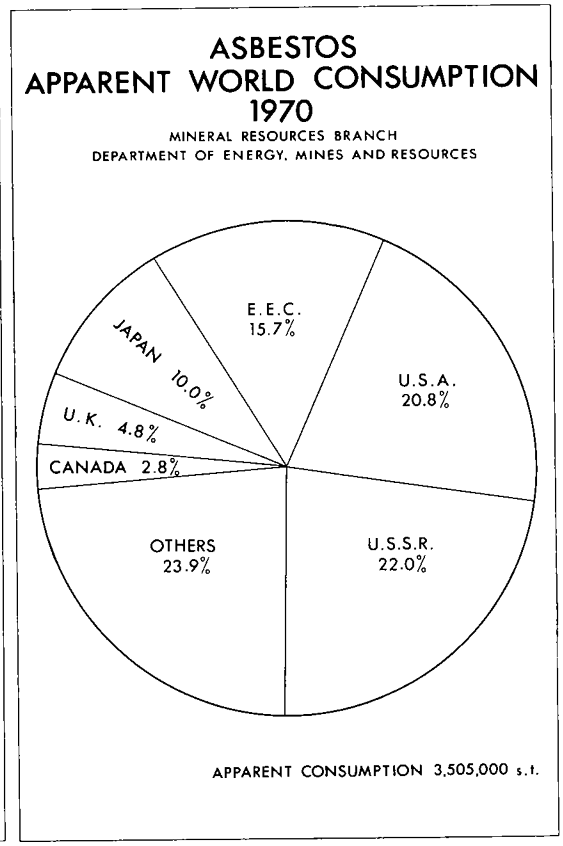
Prospective producers. Abitibi Asbestos Mining Company Limited, north of Amos, Quebec, reported 100 million tons with a content of 4 per cent cement-grade fibres, groups 4, 5 and 6. Company reports indicate that the ore could be mined by open pit at an estimated production rate of 160,000 tons of fibre a year.

McAdam Mining Corporation Limited reported 105 million tons of ore mineable by open pit at its property located 20 miles east of Chibougamau, Quebec. Tonnage includes 90 million tons grading 3.87 per cent fibre which, after beneficiation, would be reduced to 54 million tons of mill feed grading 5.80 per cent fibre.

Allied Mining Corporation was evaluating its prospect situated 43 miles south of Timmins, Ontario, where there is a reported 156 million tons averaging 9 per cent fibre consisting of groups 5, 6, 7. Feasibility studies indicate a plant capacity of 5,500 tons of ore a day to produce initially 100,000 tons of fibre a year, increasing to a maximum of 200,000 tons a year 14 years later.

Pathfinder Resources Ltd. at its Lili property, 80 miles east of Montreal has outlined 18.6 million tons grading 4.68 per cent asbestos fibre and 20.0 million tons grading 3.87 per cent fibre.





World developments

In Australia, Woodsreef Mines Limited operation in New South Wales, 58.5 per cent owned by Pacific Asbestos Limited of Canada, started production on January 31, 1972. At capacity, the plant has a rated output of 70,000 tons of asbestos fibre a year consisting of groups 4 to 7. Of this, Japan will receive 40,000 tons a year for a period of five years with option for another five years; most of the remaining production will be absorbed by Australia. Ore reserves are 27 million tons proven and 90 million tons potential.

Compania Nacional de Asbestos is constructing a mill in the State of Tamaulipas, Mexico. Completion of the project was scheduled for the end of 1971. The plant would eliminate about one third of Mexican imports or about 8,000 tons. Ore reserves are 1.3 million tons.

At Campamento in the province of Antioquia, Colombia, Asbestos Colombianos S.A. was in the preproduction stage. A yearly production of about 30,000 tons of fibre is expected in January 1973. Fifty per cent of the fibre will be grade 4T, the remainder grade 3Z, 7F and 4D. Once in full production, Colombia will have an oversupply of asbestos and will be able to export about 50 per cent of its production. Ore reserves are 2,800,000 tons proven and 4,200,000 tons probable.

In Brazil, at Cana Brava, near Uruacu in the State of Goias, the new mine of Mineracao de Amianto S.A. expects a production rate of about 17,000 tons of fibre a year in 1972.

Production capacity at the Pont-a-Mousson mine, north of Brazilia, was expected to be doubled to 2,000 tons of group 4 fibre a month by the end of 1971. Total new Brazilian production will be in the order of 30,000 tons.

A new Yugoslavian mill with a production capacity of about 40,000 tons of fibre a year started operation in 1971. Groups 4 to 7 included will be produced.

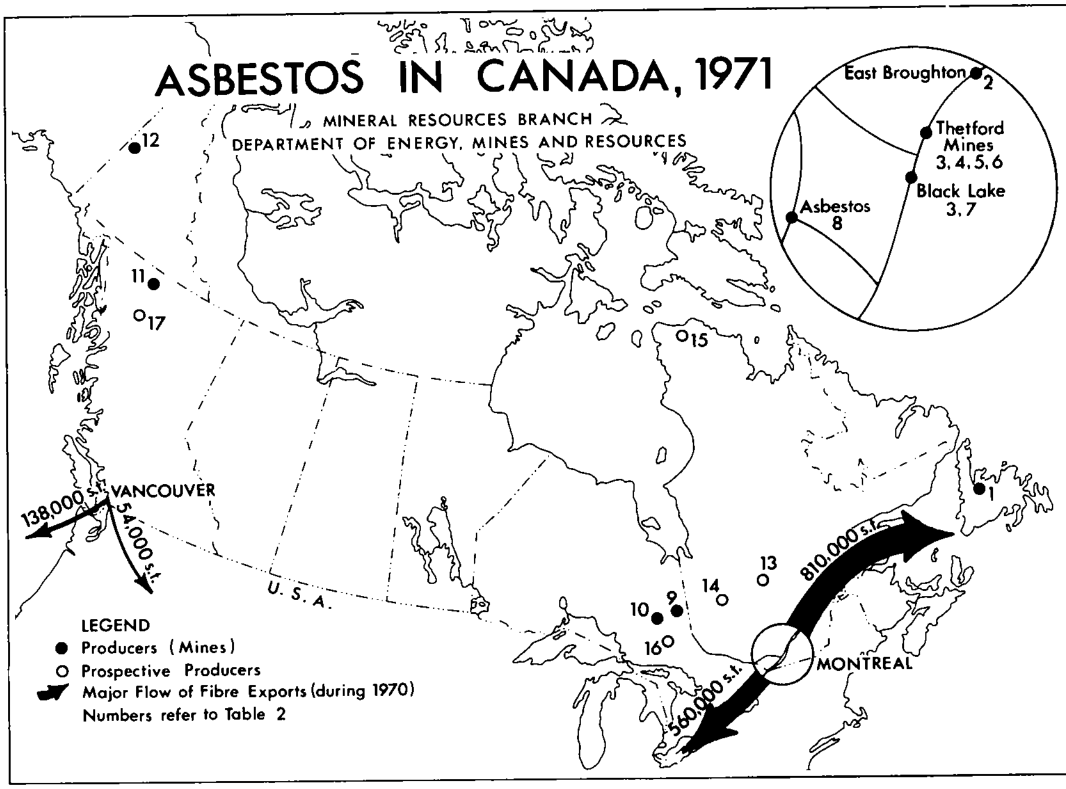
In Greece, Mabem and Hellenic Industries, 90 per cent owned by Cerro Corporation of New York, announced it was testing bulk samples of asbestos at its pilot plant. An annual production of 45,000 tons of fibre a year was planned.

Paraisten Kalkki Oy of Finland is building a new plant with a 1974 completion date.

Table 2. Canada, asbestos producers and prospective producers, 1971

	Mine Location	Mill Capacity (st ore/day)	Remarks
Producers			
1. Advocate Mines Limited	Baie Verte, Nfld.	5,000	Open pit
2. Carey-Canadian Mines Ltd.	East Broughton, Que.	4,500	Open pit, major plant expansion expected to be completed mid-1972.
3. Asbestos Corporation Limited			World's major independent asbestos producer
British Canadian mine	Black Lake, Que.	12,400	Open pit. Two milling plants
King-Beaver mine	Thetford Mines, Que.	12,000	Underground and open pit
Normandie mine	Black Lake, Que.	7,500	Open pit
4. Bell Asbestos Mines, Ltd.	Thetford Mines, Que.	3,000	Underground
5. Flintkote Mines Limited	Thetford Mines, Que.	2,000	Open pit. Closed its operations Dec. 1971
6. National Asbestos Mines Limited	Thetford Mines, Que.	3,500	Open pit
7. Lake Asbestos of Quebec, Ltd.	Black Lake, Que.	9,000	Open pit
8. Canadian Johns-Manville Company, Limited	Asbestos, Que.		Western world's largest known asbestos deposit
Jeffrey mine		33,000	Open pit. Mine and mill expansion under way
9. Hedman Mines Limited	Matheson, Ont.	300	Open pit
10. Johns-Manville Mining and Trading Limited	Timmins, Ont.		
Reeves mine		5,000	Open pit
11. Cassiar Asbestos Corporation Limited			
Cassiar mine	Cassiar, B.C.	2,400	Open pit. Completion of mill expansion by year end. New grade AZ will be produced
12. Cassiar Asbestos Corporation Limited			
Clinton Creek mine	Clinton Creek, Y.T.	4,100	Open pit
Prospective producers			
13. McAdam Mining Corporation Limited	Chibougamau, Que.	5,000	
14. Abitibi Asbestos Mining Company Limited	Amos, Que.	13,000	
15. Asbestos Corporatation Limited	Deception Bay, Que.	3,000	High-grade ore
16. Allied Mining Corporation	Timmins, Ont.	3,000	High-grade ore
17. Cassiar Asbestos Corporation Limited	Dease Lake, B.C.	–	

– Not available.



Excluding Yugoslavia, about 200,000 additional tons of fibre will be available within five years. However, most of this new production will be absorbed domestically by the producing countries.

Other developments include an experimental plant with a capacity to produce 1,700 tons a year of crocidolite fibre, being erected at Cochabamba, Bolivia under a United Nations Development Program; if results are favourable, construction of a 10,000-ton annual capacity mine and plant would follow. Preliminary studies are under way on deposits located at Santa Clara and Virgen del Valle in the province of La Rioja, Argentina. Underground prospecting work was being carried out on asbestos deposits near Enlmbe, Swaziland by Lonrho Limited.

World production (distribution) and apparent consumption

About 90 per cent of world production consists of chrysotile and by far the two major producers are Canada and Russia. Other chrysotile-producing countries include China, United States, Italy, Republic of South Africa, Rhodesia, Swaziland, Cyprus, Japan, Australia, India and Brazil. The Republic of South Africa is unique in that it is the only source of amosite in the world and the most important producer of crocidolite; in 1971 its per cent production distribution was: crocidolite 45 per cent, amosite 35 per cent, chrysotile 20 per cent. The two major producers of anthophyllite are Finland and the United States.

World production of asbestos in 1971 was estimated at 3.91 million tons compared with 3.83 million tons in 1970 and 3.60 million tons in 1969.

About half of the increase between 1969 and 1970 came from Russia and one quarter from Canada. In 1970 Canadian production was 1,662,000 tons, Russian production of fibre was estimated at 1.2 to 1.4 million tons*, while the Republic of South Africa produced 315,000 tons.

Care must be exercised when dealing with statistics on Russian production because of the lack of current data. Prior to 1968, Russian production included group 7 material which was not processed into fibre and material used for railroad ballast. If this material is included, Russian production in 1970 is estimated at 2.1 million tons.

*U.S. Bureau of Mines and industry sources.

Table 3. Canada, asbestos production and exports, 1962-71

(short tons)

	Crude	Milled	Shorts	Total
Production[1]				
1962	205	547,447	668,162	1,215,814
1963	217	579,085	696,228	1,275,530
1964	236	664,284	755,331	1,419,851
1965	163	659,598	728,451	1,388,212
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				1,661,644
1971*p*	..	..	..	1,641,000
Exports				
1962	182	532,020	632,468	1,164,670
1963	195	555,419	650,811	1,206,425
1964	214	630,515	702,747	1,333,476
1965	123	630,777	688,504	1,319,404
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*p*	115	770,135	785,313	1,555,563

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

World apparent consumption in 1970 is estimated at 3.50 million tons compared with 3.34 million tons in 1969 representing an increase of 4.8 per cent. Over half of the increase was consumed by U.S.S.R. and about 40 per cent by Japan. United States consumption at 730,000 tons continued to decrease from a high of 817,000 tons in 1968. Although individual consumption is small, the developing countries are becoming important consumers when considered as a whole.

Markets

Most of the Russian production was consumed internally and exports in the order of 350,000 tons a year were made to eastern Europe, France, Japan and West Germany, in decreasing order of importance. Canada exports more than 90 per cent of its production to over 70 countries. However, five countries account for about 70 per cent of Canadian exports: United States, Britain, Japan, West Germany and France. The Republic of South Africa, the major supplier of crocidolite and amosite, exports to countries throughout the world but its major customers are Japan, Britain, Spain, Italy and West Germany.

Fibre groups, uses and technology

In order 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 would be 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 longest fibre corresponding to 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 rather than list the products in which they are used.

Long fibres. Crudes No. 1 and 2 and Group 3–Textile industry, electrical insulation, as a filtration medium, and 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, pipe coverings, insulating mass in sprayed insulations.

Short fibres. Groups 7,8,9–Reinforcing fillers in plastics, flooring tile, asphalt, and in paints and oil well muds.

Major end uses of asbestos in the United States in 1971 were as follows: construction cement products 70%, floor tile 10%, paper products 7%, brake linings and clutch facings 3%, textiles 2%, others 8%.

The development of a glass fibre that resists alkali corrosion was announced early in 1971 by Great Britain's Fiberglass, Ltd. The product is called Cem-Fil and could be used as a partial or complete replacement for asbestos in reinforcing portland cement; its introduction on the market may have a considerable impact on the asbestos industry.

In recognition of the fact that airborne asbestos fibres may present a health hazard to workers and in certain instances to the public, the United States Government has introduced legislation governing the amount of airborne material permissible and requiring worker protection such as respirators and dust collectors.

Outlook

The outlook for asbestos in Canada should remain strong in 1972 because of the stress placed by the United States Government on new housing requirements in that country in 1972.

Except for U.S.S.R. and Canada, no new major asbestos project is expected to start production before 1975. The U.S.S.R. is not expected to increase its exports of fibre substantially in the next few years because of the growing demand for asbestos in the communist-bloc countries, as indicated by the high consumption growth rate. At present, world supply and demand are nearly in balance and Canada should be the major source of supply until at least 1975.

Prices

Prices have been gradually increased through the years to offset rising labour and production costs. However, important increases occurred during the last year and are shown below:

Quebec fob mines	(% increase per st of fibre)
1969	5 – 10
1970	3
1971	3 – 6
Cassiar, fob North Vancouver, B.C.	
1967	3 – 6
1969	3 – 9
1971	3 – 8

Important price increases were in the asbestos cement products indicating a heavier demand for groups 4, 5, 6 and partly 7 and grades AS, AX, AY.

Canadian asbestos prices quoted in Asbestos

	July 1, 1971
Quebec, fob mines	($ per short ton)
Crude No. 1	1,615
Crude No. 2	875
Group	
No. 3 (spinning fibre)	412–675
No. 4 (asbestos-cement fibre)	227–383
No. 5 (paper fibre)	164–195
No. 6 (waste, stucco, plaster)	120
No. 7 (refuse, shorts)	52–100

	Jan. 1, 1972
Cassiar, fob North Vancouver, B.C.	
Canadian group	
No. 3 (nonferrous spinning fibre)	
AAA grade	877
AA grade	697
A grade	529
No. 4 AC grade (asbestos cement)	380
(shingle fibre)	
No. 4 AK grade	263
No. 4 CP grade	248
No. 4 AS grade	228
No. 4 CT grade	223
No. 5 AX grade	208
No. 5 CY grade	147
No. 5 AY grade	147

Tariffs

Canada

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

United States

Item No.				
518.11	Asbestos, not manufactured, crude, fibres, stucco, sand and refuse containing not more than 15 per cent by weight of foreign matter	free		
		On and After Jan. 1, 1970	On and After Jan. 1 1971	On and After Jan. 1, 1972
		(%)	(%)	(%)
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 (1972) TC Publication 352.

Barite

A.F. KILLIN

Output of barite in Canada continued to decline in 1971. Production in that year was 137,000 tons, 10,251 tons less than in 1970. Exports in 1971 declined by 25,665 tons to 73,879 tons. Imports of barium carbonate in 1971 increased by 154 tons to 3,752 tons valued at $386,000.

Barite ($BaSO_4$) is of value mainly because of its weight (specific gravity 4.5) and chemical inertness. Its dominant use is as a weighting agent in drilling muds when drilling oil and gas wells. The weight factor in the drilling mud is required to counteract high oil and gas pressures in the substrata.

Barite deposits are widespread throughout the world and it is mined in many countries, principally United States, followed by West Germany, U.S.S.R. and Mexico. Canada is seventh in world production and about 90 per cent of the output is exported, 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 sediments. Pure barite is white and is most common in veins; impure barite may be near-white, grey, brown and reddish in colour. Barite was produced only in Nova Scotia and British Columbia in 1971.

Dresser Minerals Division of Dresser Industries, Inc., the main Canadian barite producer, operated a mine at Walton, Nova Scotia. The mine flooded in October 1970 and production since that time has been from stockpiles and quarried material. 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 lead-zinc sulphide ore mined in conjunction with the barite. The mine was being dewatered and development for exploration diamond drilling was under way in 1971. Production from stockpiled ore, quarried ore and low-grade waste dump material will continue in 1972. The main product is crude, lump barite that is washed and crushed to minus 2 inches, trucked 3 miles to Walton harbour and shipped in bulk to the company's grinding plants in Louisiana and Texas. A small proportion of the barite is crushed, ground, classified, pulverized and bagged for sale either in domestic or foreign markets. Some barite was recovered in the flotation processing of the argentiferous sulphides.

There were two barite producers in British Columbia in 1971. 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.

In Ontario, the operations of Extender Minerals of Canada Limited, a subsidiary of L. V. Lomas Limited, continued to be hampered by the results of a fire that destroyed the partly rehabilitated mill purchased from Geo-Pax Mines Limited. Extender Minerals plans to mine barite from veins on the shore of Mistinikon Lake, 6 miles southwest of Matachewan.

There are many occurrences of barite across Canada. Of note are occurrences in Newfoundland, at Buchans; in Nova Scotia, east of Lake Ainslie on Cape Breton Island, and near Brookfield on the mainland; in northern Ontario, in Yarrow, Penhorwood and Langmuir townships, and on McKellar Island in Lake Superior; and in northern British Columbia, at Mile 397, and north of Mile 548 on the Alaska Highway.

The Lake Ainslie deposit on Cape Breton Island is reported to contain 3 million tons of ore grading 44 per cent barite and 17 per cent fluorspar.

Table 1. Canada, barite production, trade and consumption, 1970-71

	1970		1971^p	
	(short tons)	($)	(short tons)	($)
Production (mine shipments)	147,251	1,388,125	137,000	1,170,000
Imports				
United States	7,449	346,000	11,280	531,000
West Germany	77	6,000	52	3,000
Total	7,526	352,000	11,332	534,000
Exports				
United States	94,036	900,000	70,767	636,000
Venezuela	5,508	49,000	3,112	26,000
Total	99,544	949,000	73,879	662,000
Consumption (available data)[1]	1969		1970	
Well drilling	18,000^e		28,000^e	
Paints and varnish	2,299		2,046	
Glass and glass products[2]	3,183		4,502	
Rubber goods	308		253	
Other[3]	361		134	
Total	24,151		34,935	

Source: Statistics Canada.
[1]Available data reported by consumers; breakdown by Mineral Resources Branch. [2]Includes miscellaneous chemicals, cleaners, detergents and miscellaneous products. [3]Includes glass fibre and glass wool.
^{p}Preliminary; –Nil; ^{e}Estimated.

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.

No data is available on Canadian barite consumption in 1971; available data reported by consumers for 1970 indicated domestic barite consumption of 34,935 tons. About 28,000 tons, or 80 per cent, of reported consumption was used in drilling muds. The next three most important uses are in the glass industry, the paint industry and in rubber goods.

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 character and application properties, and controls prime pigment settling and viscosity of paints. Specifications for barite in the paint industry are about 95 per cent $BaSO_4$, particle size at least minus 200 mesh, and a high degree of whiteness or light reflectance. Consumption in this industry in Canada in 1970 was 2,046 tons, 5.9 per cent of total consumption.

The glass industry uses barite to increase the workability, act as a flux, assist decoloration and increase the brilliance or lustre of the glass. Specifications call for a minimum of 98 per cent $BaSO_4$, 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 in 1970, including glass fibre and glass

Table 2. Canada, barite production, trade and consumption, 1962-1971

	Production[1]	Imports	Exports	Consumption[2]
	(st)	(st)	(st)	(st)
1962	226,600	2,427	230,903	11,249
1963	173,503	3,830	159,892	11,343
1964	169,149	3,206	156,527	13,537
1965	203,025	3,686	185,032	12,625
1966	221,376	4,165	199,054	15,184
1967	172,270	5,924	146,103	19,124
1968	138,059	7,901	116,491	22,403
1969	143,320	6,243	108,610	24,151
1970	147,251	7,526	99,544	34,935
1971^p	137,000	11,332	73,879	. .

Source: Statistics Canada.
[1]Mine shipments. [2]Available data, partially estimated by Statistics Section, Mineral Resources Branch.
^{p}Preliminary; . . Not available.

wool, amounted to 4,502 tons or 12.9 per cent of total consumption. In 1967, it was 5 per cent of total Canadian consumption.

Where used as a filler in rubber goods the specifications for natural barite vary but the main factors are whiteness and particle size range. Some requirements, perhaps where weight is most desired, may allow for the use of off-white material. In 1970, approximately 0.7 per cent of Canada consumption, 253 tons, was reported used as a filler in rubber goods.

The balance of Canada's barite consumption, approximately 134 tons or 0.4 per cent of total consumption, was used in such diverse uses as the manufacture of ceramic products, soaps and detergents.

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 are about 95 per cent $BaSO_4$, and not more than 1 to 2 percent Fe_2O_3.

Canada exported about 54 per cent of its barite production, almost wholly to United States. In 1971, exports were down to 73,879 tons from 99,544 in 1970. Imports at 11,332 tons were 51 per cent more than in 1970 and consisted mainly of ground, high-quality barite.

World review

There is worldwide production and considerable international trade in barite even though transportation costs in some cases may be almost as great as the cost of the lump material. World production of barite in 1971 was estimated at 4.08 million tons, of which about three quarters was consumed in oil well drilling. Dependence on this industry as a principal market means that demand is subject to considerable fluctuation as the tempo of oil and gas exploration varies in time and also geographically. On the other hand, oil and gas exploration is scattered throughout the world and on balance there is a consistent world demand that is most economically served by production from many countries. Viability of any deposit is dominantly influenced by transportation costs to markets.

Table 3. World production of barite, 1970-71

	1970^p	1971^e
	(short tons)	
United States	854,000	814,000
West Germany	455,000	455,000
Mexico	352,000	350,000
Italy	246,000	250,000
Ireland	177,000	175,000
Peru	143,000	150,000
Canada	147,000	137,000
France	105,000	105,000
Yugoslavia	94,000	100,000
Morocco	93,000	100,000
Other countries	1,466,000	1,450,000
Total	4,132,000	4,086,000

Source: U.S. Bureau of Mines Commodity Data Summaries, January 1972. Canada totals from Statistics Canada.
^{p}Preliminary; ^{e}Estimate.

In the United States, production of over 800,000 tons annually is derived mostly from Missouri, Arkansas, and Nevada, with smaller amounts from nine other states. The country imports about half a million tons of crude barite annually. The pattern of consumption of ground barite (excluding the barium chemicals industry) in the United States is similar to that in Canada.

Outlook

Canadian barite output in 1972 is expected to be lower than in 1971 because of the operating difficulties at the Walton mine. Exploration for new deposits and feasibility studies presently under way on known deposits, could bring about changes in the production pattern and the quantity of output in the near future. World production will depend on the strength of petroleum exploration and development.

Celestite

Celestite ($SrSO_4$), the main source of strontium, is used to produce commercial strontium compounds, principally strontium carbonate and strontium nitrate. 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 being increasingly used in small motors.

The only celestite producer in Canada, Kaiser Celestite Mining Limited, operated an open pit mine and flotation mill at Loch Lomond on Cape Breton Island, Nova Scotia. Open pit mining started in 1970 and the mine and mill operated until the winter of 1971. 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 strontium carbonate 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 plant to produce small quantities of strontium nitrate, used in pyrotechnics and tracer ammunition. Production figures are not available for publication.

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

Prices

United States prices of barite according to Engineering and Mining Journal of December 1971

	($ per short ton)
Chemical and glass grade	
Hand picked, 95% $BaSO_4$ not over 1% Fe	22.50 - 24.50
Magnetic or flotation, 96% $BaSO_4$ not over 0.5% Fe	26 - 26.50
Imported drilling mud grade, specific gravity 4.20-4.30 cif	
Gulf ports	18 - 22
Canada	15
Ground	
Water, 99½% $BaSO_4$ 325 mesh, 50-lb bags	55 - 78
Dry ground drilling mud grade, 83-93% $BaSO_4$ 3-12% Fe, specific gravity 4.20-4.30	37 - 44
Imported	
4.20-4.30 specific gravity	27

Tariffs

Canada

Item No.		British Preferential	Most Favoured Nation	General
		(%)	(%)	(%)
49205-1	Drilling mud and additives	free	free	free
68300-1	Barites			
	On and after Jan. 1, 1971	free	12	25
	On and after Jan. 1, 1972	free	10	25
92842-1	Barium carbonate	10	15	25
92818-1	Barium oxide, hydroxide, peroxide	10	15	25
93207-5	Lithopone	free	12½	25

United States

Item No.		On and After Jan. 1, 1970	On and After Jan. 1, 1971	On and After Jan. 1, 1972
427.02	Barium carbonate, natural, crude	free		
472.04	Barium carbonate, natural, ground	8.5%	7%	6%
		($ per lt)	($ per lt)	($ per lt)
472.10	Barium sulphate, natural	1.78	1.53	1.27
472.12	Barium sulphate, natural, ground	4.55	3.90	3.25
		(¢ per lb)	(¢ per lb)	(¢ per lb)
472.14	Barium sulphate, precipitated (blanc fixe)	0.43	0.35	0.3
473.72	Lithopone, containing under 30% zinc sulphide	0.6	0.52	0.43
473.74	Lithopone, containing 30% or more zinc sulphide	0.6 + 5%	0.5 + 4.5%	0.43 + 3.5%

Sources: The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division. Tariff Schedules of the United States, Annotated (1971), TC Publication 344.

Bentonite

A. F. KILLIN

Bentonite is a clay composed mainly of the mineral montmorillonite, a hydrated aluminum silicate with weakly attached cations of sodium and calcium. Bentonite has different properties depending upon the proportion of sodium or calcium. The sodium bentonites have a great physical avidity for water which provides bentonite with unique swelling properties forming gels from 15 to 20 times the original dry volume. On agitation these gels may become fluid in character and then revert to a stable gel state when quiescent. Sodium bentonite also possesses a high dry-bonding strength, especially at elevated temperatures, and this ceramic feature is important in some uses.

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 nonswelling 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", is also largely a montmorillonite clay and is very similar to nonswelling 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.

Bentonite occurs in beds of various chemical compositions and impurities, the latter consisting of quartz, chlorite, biotite, feldspar and jarosite. Natural clay may be creamy white, grey, blue, green or brown and in places beds of distinctly different colour are adjacent to each other. 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

Bentonite is generally accepted as originating from deposits of volcanic ash that have been altered by induration and weathering. In North America, the chief source is clay of Cretaceous age with other occurrences in younger Tertiary rocks. Although clay beds occur in rocks older than Cretaceous, none in Canada has been identified as bentonite; Canadian bentonite occurrences are confined to Cretaceous and Tertiary rocks at many localities in the provinces of Manitoba, Saskatchewan, Alberta and British Columbia. In the Truax area of Saskatchewan, south of Avonlea, Indusmin Limited was exploring a bentonite occurrence where diamond drilling has indicated 4,000,000 tons of bentonite material. Preliminary tests indicate that the bentonite would be suitable for use in the pelletizing of iron ore and in iron foundries.

Three companies mine and process bentonite in Canada; statistics on total production 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, 9 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 an oil well drilling mud additive but some is used as a binder in foundry sands and in feed pelletizing, as a fire-retardant additive to water and as a sealer for farm reservoirs.

In Manitoba, Pembina Mountain Clays Ltd. mines

Table 1. Canada, bentonite imports and consumption, 1970-71

	1970		1971p	
	(short tons)	($)	(short tons)	($)
Imports				
Bentonite				
United States	291,210	2,678,000	287,492	2,702,000
Greece	52,944	598,000	59,308	593,000
Total	344,154	3,276,000	346,800	3,295,000
Activated clays and earths				
United States	10,332	1,723,000	12,518	1,685,000
France	121	40,000	171	69,000
West Germany	–	–	10	3,000
Greece	20,944	236,000	–	–
Total	31,397	1,999,000	12,699	1,757,000
Fuller's earth				
United States	11,431	315,000	10,643	305,000
Britain	2	...	4	...
Total	11,433	315,000	10,647	305,000

	1969	1970
	(short tons)	
Consumption[1] (available data)		
Pelletizing iron ore	211,209	243,744
Well drilling	18,327	24,833
Foundries	43,024	34,363
Chemicals	2,316	2,038
Fertilizer stock and poultry feed	225	69
Paint and varnish	175	219
Pulp and paper	198	191
Other products[2]	2,986	1,764
Total	278,460	307,221

Source: Statistics Canada.
[1]Includes fuller's earth. Breakdown by Mineral Resources Branch. [2]Explosives, frits and enamels, refractory brick and cements, ceramic products, gypsum and concrete products, petroleum refining and refining vegetable oils and other miscellaneous minor uses.
pPreliminary; – Nil; ... Less than one thousand dollars.

nonswelling bentonite from the Upper Cretaceous Vermilion River Formation, 19 miles northwest of Morden, which is in turn 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 decolorizing and purifying mineral vegetable oils, animal fats and tallows.

Uses, consumption and trade

Bentonite has many uses but 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

Table 2. Canada, bentonite imports and consumption, 1962-71

	Imports[1]		Consumption[2]
	(short tons)	($)	(short tons)
1962	. .	1,524,080	57,237
1963	. .	2,005,337	93,512
1964	123,533	1,659,076	161,695
1965	192,170	2,310,566	176,536
1966	204,038	2,606,000	201,022
1967	235,451	3,346,000	215,928
1968	323,093	4,041,000	231,349
1969	311,327	4,638,000	278,460
1970	386,984	5,590,000	307,221
1971[p]	370,146	5,357,000	. .

Source: Statistics Canada.
[1] Includes fuller's earth and activated clays and earths.
[2] Includes fuller's earth.
[p] Preliminary; . . Not available.

particle size of the concentrate.

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 drill hole with a gel. It also serves as a lubricant and helps to keep the drill cuttings in suspension.

Swelling bentonite serves as a binder in moulding sands used by iron and steel foundries. Nonswelling 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 subsurface 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 nonswelling bentonite is used in pelletizing stock feed, as a carrier for pesticides, and as a cleaning powder for animals.

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

Consumption of bentonite in Canada has increased greatly in the last decade (see Table 2). This has been largely due to 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; approximately 35,000 tons are used annually in Canada.

Imports of bentonite from the United States decreased slightly in 1971 and Greek imports increased a small amount. Small 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. The high standards of Wyoming bentonite are not common and this material is transported over distances such that transportation costs commonly exceed its value at the mine, in some cases by several times. Canada is the main importer from the United States but some bentonite moves to Australia and western Europe. Nonswelling 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 the present time, the most suitable material for this purpose is imported from the United States. The development of a Canadian source of suitable material for pelletizing will depend on tests being carried out on material from Saskatchewan, competitive mining costs and freight rates. The slowdown in import growth is attributed to a decrease in the rate of pellet-plant construction. The building of a 6-million-ton-a-year iron ore pellet plant at Sept Îles, Quebec, by 1973, will require an increased supply of bentonite. No major changes in production and consumption in industries other than in ore pelletizing are foreseen.

Prices

United States bentonite prices quoted in Oil, Paint and Drug Reporter, December 27, 1971

	($)
Bentonite, domestic, 200 mesh, bags, car lots, fob mines, per ton	14-14.40
Bentonite, imported Italian white, high gel, bags, 5-ton lot ex-warehouse, per ton	116.60

Tariffs

Canada

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

United States

Item No.		On and After Jan. 1, 1970	On and After Jan. 1, 1971	On and After Jan. 1, 1972
			(¢ per long ton)	
521.61	Bentonite	56	48	40
521.51	Fuller's earth not beneficiated	35	30	25
521.54	Wholly or partly beneficiated	70	60	50
			(¢ per lb)	
521.87	Clays, artificially activated with acid or other material	0.07 +8.5% ad val	0.06 +7% ad val	0.05 +6% ad val

Source: The Custom Tariff and Amendments, Department of National Revenue, Custom and Excise Division, Ottawa. Tariff Schedules of the United States, Annotated (1970) T.C. Publication 304.

Bismuth

M. GAUVIN

Bismuth is obtained in Canada as a byproduct in the processing of certain lead-zinc, lead-zinc-copper, molybdenum and copper ores. The more important sources during 1971 were molybdenum ores mined in the Malartic district of northwestern Quebec, lead-zinc ores produced in southeastern British Columbia and copper ores mined near Gaspé in eastern Quebec. Minor amounts are recovered from lead-zinc-copper ores mined in northeastern New Brunswick and from silver-cobalt ores produced in the Cobalt-Gowganda area of northern Ontario.

Based on preliminary figures bismuth production in Canada in 1971 totalled 267,000 pounds valued at $1,331,000, compared with 590,340 pounds valued at $3,370,554 in 1970. The sharp drop in production in 1971 is accounted for mostly by the closure of mines in northwestern Quebec.

In 1971 world production of bismuth excluding United States production, as estimated by the United States Bureau of Mines, was some 8.9 million pounds, the same as in 1970. Japan was the leading producer with an output of 2.1 million pounds followed by Peru, Bolivia and Mexico. The United States does not publish its production statistics.

World demand for bismuth dropped significantly during the year, especially in the United States where consumption was an estimated 20 per cent less than the 2.2 million pounds consumed in 1970. The decline was reflected by a sharp drop in the price of bismuth, which reacts strongly to changes in demand and supply. The producer price in the United States dropped from $6 to $3.50 a pound during the year, while dealer prices, which were at a premium over the producer price during 1970, were at a discount during all of 1971.

Bolivia, traditionally a major supplier of bismuth ore, continued construction of its first bismuth smelter and refinery for the production of bismuth metal. The plant is owned by the Corporacion Minera de Bolivia (Comibol). Its planned annual rated capacity is 1.85 million pounds of bismuth metal, and production is scheduled to begin early in 1972. It is being built at Telemayu in Potosi Department. Feed for the smelter is expected to consist mainly of local ores mined from Comibol mines for their bismuth content. The Tasna mine, the country's principal bismuth producer, is one of the few mines in the world worked primarily for bismuth.

Australia is expected to become the western world's largest bismuth producer in 1973. Construction of a copper smelter and bismuth recovery plant by Peko-Wallsend Ltd. at Tennant Creek about 600 miles south of Darwin in the Northern Territory was 50 per cent complete at the end of 1971. Peko will use the plant to treat copper concentrates currently exported to Japan containing an appreciable amount of bismuth, from some of its mines in the Northern Territory. It is expected that the new plant will have an annual bismuth output of up to 2 million pounds.

Authorized sales of bismuth from the United States Government stockpile totalled 15,500 pounds in 1971. Some 300,000 pounds of bismuth were authorized for sale by Public Law 90-153 signed by President Nixon July 10, 1970. At December 31, 1971, 235,457 pounds of this current disposal authorization remained unsold. Stockpiled bismuth at the end of 1971 amounted to 2,335,457 pounds and the stockpile objective at that time was 2,100,000 pounds.

Outlook

World demand for bismuth is expected to follow the general trend of economic activity of the world's industrialized nations. Bismuth sales in the United States picked up about 25 per cent in the last quarter of 1971 possibly because of the producer price cut in November. World supply is not expected to decrease,

Table 1. Canada, bismuth production and consumption, 1970-71

	1970		1971p	
	(pounds)	($)	(pounds)	($)
Production, all forms[1]				
British Columbia	132,135	828,486	109,000	598,000
Quebec	404,297	2,204,066	106,000	448,000
New Brunswick	39,717	249,025	37,000	203,000
Ontario	13,701	85,905	15,000	82,000
Northwest Territories	490	3,072	–	–
Total	590,340	3,370,554	267,000	1,331,000
Consumption, refined metal (available data)				
Fusible alloys and solders	3,984		. .	
Other uses[2]	20,564		. .	
Total	24,548		. .	

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.
pPreliminary; . . Not available; – Nil.

with the new smelter in Bolivia in operation in 1972 and the Australian smelter scheduled to go on stream in 1973.

Domestic sources

British Columbia. Cominco Ltd. remained the only producer of bismuth metal in British Columbia, deriving 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 from custom shippers. Lead bullion produced from the smelting of these concentrates contains about 0.05 per cent bismuth. Bismuth is recovered as 99.99+ per cent pure metal from the treatment of residues resulting from the electrolytic refining of the lead bullion. For use in research and in the electronics industry this bismuth is further processed to give it a purity of up to 99.9999 per cent.

Quebec. For many years the molybdenite mines of northwestern Quebec which produce bismuth as a byproduct were Canada's largest producers of bismuth. They produced metallic bismuth of about 95 per cent purity. However, during five months of 1971 they were closed because of the poor market for their products.

Preissac Molybdenite Mines Limited ceased operation in April and has not resumed production. Molybdenite Corporation of Canada Limited, located in Lacorne Township 12 miles northeast of Malartic, suspended operations in the spring of 1971. The mine was reopened at the end of September when the Quebec Department of Natural Resources arranged to become the operator of the mine for one year.

Three principal steps are involved in the process of separating the bismuth from the molybdenite ore. A bulk concentrate containing about 8 per cent bismuth is produced by flotation. By leaching this concentrate

Table 2. Canada, bismuth production, exports and consumption, 1962-71

	Production (all forms)[1]	Exports[2]	Consumption[3]
		(pounds)	
1962	425,102	382,182	37,200
1963	359,125	399,772	47,800
1964	399,958	300,073	53,700
1965	428,759	. .	48,300
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
1971p	267,000	. .	. .

Source: Statistics Canada.
[1]Refined bismuth metal from Canadian ores, plus recoverable bismuth content of bullion and concentrates exported. [2]Refined and semirefined bismuth metal. [3]Refined bismuth metal reported by consumers.
pPreliminary; . . Not available.

Table 3. Estimated world production of bismuth, 1969-71

	1969	1970	1971^e
		(pounds)	
Japan (metal)	1,531,000	2,000,000	2,100,000
Peru	1,500,000	1,682,000	1,700,000
Bolivia	1,476,000	1,373,000	1,400,000
Mexico	1,336,000	1,300,000	1,400,000
Canada (metal)	579,000	590,000	267,000
People's Republic of China (in ore)	551,000^e	551,000^e	. .
Australia (in concentrates)	496,000	518,000	. .
South Korea (metal)	245,000	234,000	300,000
Romania (in ore)	176,000	176,000	. .
Yugoslavia (metal)	226,000	166,000	250,000
Other countries	344,000	347,000	1,550,000
Total	8,460,000[1]	8,937,000[1]	8,967,000

Source: Statistics Canada for Canada; for remaining countries, U.S. Bureau of Mines, *Minerals Yearbook* Preprint, 1970 and U.S. Commodity Data Summaries, January 1972.
[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.
[p]Preliminary; [e]Estimated; . . Not available.

with hydrochloric acid the bismuth is separated as bismuth oxychloride which is then smelted in electric-arc furnaces. The resulting bullion is cast into ingots containing about 95 per cent bismuth, minor amounts of lead and silver and traces of copper, iron and antimony.

Gaspé Copper Mines, Limited recovered bismuth in metal ingots from the treatment of flue dust derived from its copper-smelting operation at Murdochville, on the Gaspé Peninsula. Production statistics of the company are not available.

New Brunswick. The Smelting Division of Brunswick Mining and Smelting Corporation Limited (formerly East Coast Smelting and Chemical Company Limited) produced bismuth metal at its plant at Belledune. The output was derived as a byproduct from the processing of lead and lead-zinc concentrates produced by the company's Mining Division at its mines near Bathurst. Production in 1971 amounted to 26,605 pounds of refined bismuth grading 99.9 per cent or better, compared with a production of 7,960 pounds in 1970. The Kroll-Betterton process is used to treat the desilverized lead bullion and produce a bismuth-lead-calcium-magnesium dross. The dross is then pyro-metallurgically refined with chlorine to produce bismuth metal. Substantial amounts of bismuth were contained in the lead concentrates produced at the lead-zinc-copper-silver property of Nigadoo River Mines Limited in the Bathurst area. The byproduct bismuth is recovered by the custom lead smelter to which the concentrates are sold. Nigadoo River Mines Limited was not producing in the last month of the year and on January 4, 1972 it announced the immediate suspension of all operations.

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 oxychoride which

Table 4. United States consumption of bismuth, by principal uses

	1970	1971^p
	(pounds)	
Fusible alloys	643,691	480,807
Other alloys	12,998	15,592
Pharmaceuticals[1]	1,183,035	704,924
Experimental uses	109	1
Metallurgical additives	361,484	352,024
Other uses	8,324	6,000^e
Total	2,209,641	1,559,348

Source: Mineral Industry Surveys, United States Department of the Interior, Bureau of Mines, Bismuth in the Fourth Quarter 1971.
[1]Includes industrial and laboratory chemicals.
[p]Preliminary; [e]Estimated.

imparts a 'pearlescent' glow to eye shadow, hair spray, lipstick, nail polish and powders now comprise one of the largest end-use markets of bismuth.

Another important outlet for the metal is in fusible or low-melting-point alloys for fire-protection devices, electrical fuses and solders. Many of these alloys contain 50 per cent or more bismuth with the chief additive metals being cadmium, lead and tin. The manufacture of jet engines also accounts for substantial quantities of these alloys. Until 1969, bismuth-molybdate catalysts had been used in the production of acrylic plastics but a catalyst manufactured from depleted uranium has taken over this market.

Type metal contains bismuth because bismuth expands on solidification and imparts expansion to its alloys. It is also used as an important additive to improve the machinability of aluminum alloys, malleable irons and steel alloys, and for holding lenses and positioning parts in aerospace work. The United States Atomic Energy Commission uses bismuth in many nuclear research applications because of the metal's low thermal neutron absorption rate.

Prices

The Canadian price for bismuth, as quoted by Cominco Ltd., for bars 99.99 per cent pure, was $6 a pound in lots of one ton or more from January 1 to July 21, 1971. Between July 22 and December 1, Cominco's price was $4.75 and it dropped again to $3.50 from December 2 to December 31. The United States price in ton lots as published by *Metals Week* and expressed in United States currency showed the same trend. It was $6 a pound from January 1 to July 11, $4.75 a pound from July 12 to November 23 and $3.50 a pound from November 24 to December 31.

Tariffs

Canada

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

United States

601.66	Bismuth ores and concentrates	free		
632.10	Bismuth metal, unwrought; waste and scrap	free		
	Bismuth alloys			
632.64	Containing by weight not less than 30% lead	free		
		On and After January 1		
		1970	1971	1972
			(% ad val.)	
632.66	Other	12.5	10.5	9
633.00	Bismuth metal, wrought			

Sources: The Custom Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa. Tariff Schedules of the United States Annotated (1971) TC Publication 344.

Cadmium

G. S. BARRY

Cadmium in nature occurs predominantly as a sulphide greenockite and is closely associated with sphalerite the common zinc ore mineral. It follows zinc through the milling process and is recovered as a byproduct of zinc refining. Canadian zinc ores contain up to 0.07 per cent cadmium and zinc concentrates contain up to 0.7 per cent cadmium. Most of the cadmium is recovered from concentrates grading 0.1 to 0.3 per cent.

Canadian production in 1971 as reported by Statistics Canada was 4,132,000 pounds, a slight decrease from 1970. This amount represents the metallic cadmium recovered at domestic smelters from Canadian ores, plus the recoverable content that was paid for by foreign smelters that treated Canadian zinc concentrates.

Cadmium is recovered at electrolytic plants as a precipitate, or oxide sponge produced during the purification of the zinc electrolyte. In Canadian plants, the metal is then produced either by the electrolytic process, where cadmium is plated out in electrolytic cells, or by a purification process in which the sponge is briquetted, melted in an electric furnace, de-zinced and cast. At zinc primary distillation plants, cadmium is reduced and vapourized with zinc in a retort or furnace. The vapour is condensed and cadmium (B.P. 776°C) is separated from zinc (B.P. 905°C) by fractional redistillation.

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; and Canadian Electrolytic Zinc Limited, at Valleyfield, Quebec. The Smelting Division, Brunswick Mining and Smelting Corporation Limited (formerly East Coast Smelting and Chemical Company Limited) recovered small amounts of cadmium and a cadmium-zinc alloy at its Belledune, New Brunswick, lead-zinc smelter and exported this alloy to Europe for refining. In 1971 metallic cadmium produced in Canada totalled 1,568,787 pounds compared with 1,844,706 pounds in 1970.

The United States continued to be the world's largest producer of metal with a smelter output in 1971 of 3,946 tons from primary and secondary sources. This is considerably less than the recorded totals of 4,733 tons in 1970 and 6,323 tons in 1969. Japan, the U.S.S.R. and Canada in that order are the next largest cadmium metal producers. On the mine production basis, Canada is the world's third largest supplier after the United States and the U.S.S.R.

Refined cadmium was exported to seven countries with the United States, Britain and The Netherlands importing 91 per cent of Canada's exports. Britain no longer maintained its past dominant position as the main customer.

Canadian consumption data for 1971 is not available. It is estimated at 124,959 for 1970, indicating a further drop from the 1969 level. Apparent consumption in the United States which fell sharply from 15.1 million pounds in 1969 to 9.1 million pounds in 1970 rebounded modestly to 10.0 million pounds in 1971. Consumption in Japan and most European countries, however, remained at low levels. Cadmium consumption can only be estimated crudely as "apparent" since there is no way to check inventory changes at the consumers' end and these are known to fluctuate widely.

Table 1. Cadmium production, exports and consumption, 1970-71

	1970		1971p	
	(pounds)	($)	(pounds)	($)
Production				
All forms[1]				
Ontario	2,351,277	8,370,546	2,567,000	4,882,000
British Columbia	939,310	3,343,944	1,088,000	2,111,000
New Brunswick	158,901	565,688	135,000	262,000
Quebec	295,413	1,051,670	137,000	237,000
Yukon	73,463	261,528	83,000	161,000
Manitoba	188,682	671,708	81,000	157,000
Saskatchewan	93,707	333,597	27,000	52,000
Northwest Territories	207,200	737,632	14,000	27,000
Total	4,307,953	15,336,313	4,132,000	7,889,000
Refined[2]	1,844,706		1,568,787	
Exports				
Cadmium metal				
Britain	1,257,949	4,114,000	436,640	836,000
United States	270,395	1,063,000	380,225	664,000
Netherlands	–	–	492,791	626,000
Belgium & Luxembourg	2,060	9,000	70,628	83,000
India	2	...	35,986	54,000
West Germany	9,223	12,000	22,046	26,000
Venezuela	800	3,000	400	9,000
Other countries	8,606	37,000	73	2,000
Total	1,549,035	5,238,000	1,438,789	2,300,000
Consumption (cadmium metal)[3]				
Plating	85,075		86,873	
Solders	12,329		4,301	
Other products[4]	27,555		26,221	
Total	124,959		117,395	

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.
pPreliminary; – Nil; . . . Less than $1,000.

The large imbalance that persisted throughout 1971 between supply and demand caused prices to drift to their lowest levels since the late 1950's. The United States and Canadian producer prices that fell sharply in 1970 dropped from $2.25 in January to $1.50 in August 1971. Merchant cadmium metal was offered at substantial discounts in Japan, Europe and the United States, reportedly reaching a low of about $1.60 in the first part of the year and $1.15 to $1.18 in the second half of 1971. Japanese smelting companies were cited for making sales in the United States at "less than fair market value" and were awaiting hearings before the Tariff Commission at the end of the year. Canadian producers were not included in this investigation.

During the year, Japanese producers have considerably reduced their inventories whereas the United States producers' inventories increased to a high of 6.09 million pounds which is 27 per cent higher than at the end of 1970. The United States Government stockpile contained 10,147,806 of which 4,147,806 pounds authorized for release since July 1970 remained unsold.

Signs of a strong upturn in demand that were barely discernible in December 1971 were evident in January 1972. The outlook for 1972 is good particularly for the major plating market which is strongly tied to automobile production. Demand from the pigment and plastic industry is also expected to improve significantly.

Table 2. Canada, cadmium production, exports and consumption, 1962-71

	Production		Exports	
	All Forms[1]	Refined[2]	Cadmium Metal	Consumption[3]
	(lb)	(lb)	(lb)	(lb)
1962	2,604,973	2,435,000	2,340,289	232,000
1963	2,475,485	2,354,000	1,939,110	209,000
1964	2,772,984	2,501,921	1,623,679	178,000
1965	1,755,925	1,790,488	1,364,645	172,000
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[p]	4,132,000	1,568,787	1,438,789	117,395

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.

Table 3. World smelter production of cadmium

	1970	1971[e]
	(short tons)	
United States	4,732	3,650
Japan	2,801	2,700
U.S.S.R.	2,535	2,500
Canada	2,154	2,066
Belgium	1,205	995
Federal Republic of Germany	1,141	770
Australia	659	645
Poland	606	615
France	582	595
Italy	468	425
Other countries	2,280	2,200
Total	19,163	17,161

Sources: World Bureau of Metal Statistics; for Canada, Statistics Canada.
Note: Data are for production of cadmium as unwrought metal from domestic and imported materials. Secondary metal is included where known, but the total in aggregate is less than one per cent of the world total. 1971 figures from United States Bureau of Mines, Commodity Data Summaries, January 1972.
[e]Estimated.

Domestic production

Table 4 lists data on cadmium production as reported by individual mines. Additional information is given in the following review by provinces.

New Brunswick. Brunswick Mining and Smelting Corporation Limited operated two mines, and its Smelting Division operated a zinc-lead Imperial Smelting Furnace (ISF) at Belledune near Bathurst. The company produced 37,358 pounds of cadmium in 1971. It converted its ISF operation to a lead blast furnace late in 1971 and from that time exported all its zinc concentrates for treatment at foreign smelters.

Quebec. The copper-zinc mines of northwestern Quebec have small amounts of cadmium in their ores, but in most cases it is too little to be paid for under the smelter contracts. Zinc concentrates contain from 0.06 to 0.16 per cent cadmium. Canadian Electrolytic Zinc Limited (CEZ) at Valleyfield recovers refined cadmium from zinc concentrates produced by the Mattagami and Orchan mines. Typical concentrates from these mines grade 0.10 per cent and 0.06 per cent cadmium respectively. CEZ also treats concentrates from the Geco mine, Ontario. Production at the CEZ plant in 1971 was 378,000 pounds, considerably lower than the 514,000 pounds reported for 1970.

Ontario. Ecstall Mining Limited, at Timmins, the largest producer of cadmium in Canada, had a record year, producing 3.2 million pounds in 1971. The company exported all of its zinc concentrates which typically contain about 0.25 per cent cadmium. It is completing the construction of an electrolytic zinc plant to be opened in 1972 that will have a cadmium refinery with a capacity of 1,000,000 pounds a year. Other zinc-copper mines in Ontario produce concentrates carrying low to moderate cadmium values. Noranda Mines Limited's Geco mine at Manitouwadge is the second largest producer next to Ecstall. Its concentrates, grading approximately 0.32 per cent cadmium, are treated by Canadian Electrolytic Zinc Limited.

Manitoba and Saskatchewan. The zinc concentrates produced in these two provinces are treated at the electrolytic zinc plant of Hudson Bay Mining and Smelting Co., Limited at Flin Flon. Production at this plant was 145,857 pounds of cadmium in 1971.

British Columbia. Metallic cadmium, amounting to 597 tons was recovered at the metallurgical works of Cominco Ltd. at Trail. Cominco treats ores and concentrates from its own mines in British Columbia, from its subsidiary Pine Point Mines Limited, N.W.T., and, on a custom basis, from various mining operations in British Columbia and other provinces.

Yukon Territory. United Keno Hill Mines Limited mines silver-lead-zinc ore high in cadmium, recovering

Table 4. Companies reporting cadmium production, 1971 (and 1970)

Company and Location	Mill Capacity	Grade of Zinc Concentrates: Cadmium	Zinc	Lead	Copper	Silver	Zinc Concentrate Produced	Cadmium Contained in Zinc Concentrate	Remarks
	tons ore/ day	%	%	%	%	oz/ton	tons	pounds	
Newfoundland									
American Smelting and Refining Company, Buchans Unit, Buchans	1,250 (1,250)	0.21 (0.22)	56.23 (57.12)	4.07 (. .)	0.75 (0.73)	4.68 (4.36)	29,870 (64,325)	127,000 (284,000)	Zinc concentrates exported to Europe; operations closed by strike, June 21 to Nov. 1971
New Brunswick									
Nigadoo River Mines Limited, Robertville	1,000 (1,000)	0.69 (0.68)	46.00 (46.39)	1.49 (1.30)	1.12 (0.93)	5.79 (. .)	14,379 (13,434)	199,274 (178,377)	Operations suspended Jan 4, 1972
Quebec									
Sullivan Mining Group Ltd., Stratford Centre, Cupra mine	1,400 (1,500)	0.28 (. .)	57.05 (. .)	0.53 (. .)	1.40 (. .)	1.12 (. .)	7,127 (. .)	39,911 (. .)	Cupra Division operates concentrator for all three mines
D'Estrie mine	– (–)	0.28 (. .)	56.76 (. .)	0.73 (. .)	2.11 (. .)	1.63 (. .)	2,906 (. .)	16,272 (. .)	
Weedon mine	– (–)	0.28 (. .)	53.11 (. .)	– (. .)	2.56 (. .)	1.36 (. .)	1,636 (. .)	9,162 (. .)	
Ontario									
Ecstall Mining Limited, Timmins	10,000 (9,000)	. . (. .)	52.8 (52.2)	. . (. .)	0.36 (0.32)	4.3 (3.5)	595,413 (582,844)	3,214,000 (2,927,776)	Concentrates exported; beginning mid-1972, zinc electrolytic plant will produce about 1,000,000 pounds of cadmium
Noranda Mines Limited, Geco Division, Manitouwadge	5,000 (5,000)	. . (0.34)	53.89 (52.53)	– (–)	0.68 (0.80)	1.81 (2.06)	146,552 (79,479)	. . (. .)	In zinc concentrates treated by Canadian Electrolytic Zinc Limited, Valleyfield, Quebec
Willroy Mines Limited (incl. Willecho mine) Manitouwadge	1,600 (1,700)	. . (. .)	52.77 (53.23)	0.07 (0.12)	0.54 (0.45)	1.20 (1.43)	22,522 (24,150)	81,001 (. .)	

Table 4 (cont'd)

Company and Location	Mill Capacity	Grade of Zinc Concentrates: Cadmium	Zinc	Lead	Copper	Silver	Zinc Concentrate Produced	Cadmium Contained in Zinc Concentrate	Remarks
	tons ore/ day	%	%	%	%	oz/ton	tons	pounds	
Manitoba and Saskatchewan									
Hudson Bay Mining and Smelting Co., Limited, Flin Flon	7,500 (6,000)	. . (. .)	47.9 (47.4)	0.3 (0.3)	0.9 (0.8)	0.9 (1.1)	45,900 (102,100)	274,042 (338,343)	Operation closed by strike from Jan. to June 1971
British Columbia									
Canadian Exploration, Limited, Salmo	– (1,900)	– (. .)	– (56.97)	– (1.5)	– (. .)	– (. .)	– (9,830)	– (83,400)	
Cominco Ltd., Sullivan Mine, Kimberley	10,000 (10,000)	. . (. .)	48.60 (48.4)	5.46 (5.5)	– (–)	. . (2.4)	202,320 (204,357)	. . (. .)	Cominco's total output of cadmium from all sources, 597 tons in 1971
Copperline Mines Ltd., Golden	700 (600)	. . (0.36)	. . (52.14)	. . (2.11)	. . (. .)	. . (9.93)	. . (2,546)	. . (18,336)	
Kam-Kotia-Burkam Joint Venture, Silmonac mine, Sandon	150 (133)	0.42 (0.43)	54.2 (55.1)	. . (7.0)	– (–)	79.0 (72.2)	3,998 (1,343)	33,721 (11,640)	
Reeves MacDonald Mines Limited, Remac									
Reeves mine	1,000 (1,200)	0.33 (0.32)	50.77 (51.5)	1.99 (1.9)	– (–)	1.25 (0.91)	1,996 (8,707)	13,291 (55,650)	Reeves mine closed in July 1971
Annex mine		0.62 (0.65)	50.87 (50.2)	0.79 (1.0)	– (–)	4.96 (8.1)	25,962 (11,821)	323,740 (150,207)	
Teck Corporation Limited, Beaverdell	110 (110)	0.42 (0.33)	45.17 (30.29)	1.99 (2.5)	– (–)	54.50 (44.35)	306 (444)	2,592 (2,938)	Zinc concentrates treated at Trail, B.C.
Western Mines Limited, Buttle Lake, V.I.	1,000 (1,000)	0.25 (0.26)	53.20 (53.65)	1.38 (2.36)	1.09 0.95	3.70 (3.36)	38,003 (35,580)	193,550 (189,061)	
Yukon Territory									
United Keno Hill Mines Limited, Elsa	550 (500)	0.70 (0.64)	54.3 (51.05)	0.9 0.54	– (–)	12.4 (7.88)	6,388 (7,505)	89,024 (104,876)	
Venus Mines Ltd. Carcross	300 (300)	. . (2.2)	. . (49.7)	. . (4.5)	. . (–)	. . (38)	. . (229)	. . (10,071)	Operations suspended in June 1971

89,029 pounds in 1971. Another small cadmium producer, Venus Mines Ltd., which was brought into production in 1970, ceased operations in June 1971. Anvil Mining Corporation Limited is believed to be exporting zinc concentrates low in cadmium, which is not paid for.

Northwest Territories. Pine Point Mines Limited continued to be the only supplier of cadmium in the Northwest Territories shipping zinc concentrates which are mainly smelted at Trail. The Pine Point ores have a low cadmium content.

Uses

Cadmium 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 both 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 esthetic 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.

Cadmium-plated articles 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 in both black-and- white and colour television tubes. 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 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 exclusively.

Another growing application is in the production of nickel-cadmium storage batteries. These batteries are considerably more expensive than the standard lead-acid battery, but 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, missiles and ground equipment for polar regions, as well as in portable items such as battery-operated shavers, toothbrushes, drills and hand saws.

Outlook

A key to a resumption of growth in cadmium consumption is a continuing recovery in general economic activity matched with consumer confidence in stability of the price. Consumer inventories are reportedly at rock bottom levels and since cadmium is consumed in small quantities by very many end-users a rather small inventory buildup by individual users, as prices turn about, will rapidly shift stocks from producers to consumers. As in the past such shifts in "apparent" demand may involve the transfer of millions of pounds of metal. At the end of 1971 the United States producer stocks were at a very high level, reported at just over 6 million pounds. Elsewhere in the world, however, particularly in Japan, producer stocks were apparently almost depleted.

The outlook therefore is for a sharp turnabout in "apparent" consumption in 1972 and prices strengthening and maintaining a level of $2 to $3 per pound for most of 1972. Consumers may absorb part of the United States stockpiled surplus which would have a stabilizing effect on price fluctuations. Balanced supply and demand factors and stable prices should persist into 1973. Pollution problems that plagued the industry, particularly in Japan, for the last two years appear to be under control.

Prices

Canadian producers' cadmium prices throughout 1971, as quoted in The Northern Miner
sticks, bars, balls, 99.98%

Effective Date	Lots of 5,000 lb and Over	Lots Under 5,000 lb
	($ per lb)	($ per lb)
January 7	2.35	2.55
June 3	2.25	2.45
August 5	1.50	1.70

United States producers' prices throughout 1971, as quoted by Metals Week

Effective Date	One-Ton Lots	Lots of Less than One Ton
	($ per lb)	($ per lb)
January 11	2.25	2.30
August 26	1.50	1.55

Tariffs

Canada

Item No.		British Prefer- ential	Most Favoured Nation	General
32900-1	Cadmium in ores and concentrates	free	free	free
35102-1	Cadmium metal, not including alloys in lumps, powders, ingots or blocks	free	free	25%

United States

Item No.				
601.66	Cadmium in ores and concentrates	free		
		On and After Jan. 1, 1970	On and After Jan. 1, 1971	On and After Jan. 1, 1972
632.14	Cadmium metal, unwrought, waste and scrap (duty on waste and scrap suspended on or before June 30, 1973)	1¢ per lb	free	free
633.00 632.84	Cadmium metal, wrought } Cadmium alloys, unwrought }	12.5%	10.5%	9%

Sources: The Custom Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa. Tariff Schedules of the United States, Annotated (1971), TC Publication 344.

Calcium

C.J. CAJKA

Calcium, a member of the alkaline earth family, is silvery white in colour, is extremely soft and ductile, has a low tensile strength, tarnishes rapidly under atmospheric conditions, and is a powerful reducing agent. The fifth most abundant element in the earth's crust, calcium occurs chiefly in limestone and dolomite. High-grade calcium limestone deposits are the principal sources of calcium metal.

Metallic calcium can be obtained by thermal and electrolytic methods. There are only three producers of metallic calcium in the noncommunist world: Chromasco Corporation Limited in Canada, formerly Dominion Magnesium Limited; Charles Pfizer and Co. Inc. in the United States; and Planet-Wattohm S.A., a subsidiary of Compagnie de Mokta, in France. All three use the Pidgeon process which is a thermal reduction method.

Canada continued to be a leading international supplier of calcium metal although, for the second consecutive year, production declined. Producers' shipments of calcium metal and calcium metal used in production of calcium alloys totaled 304,000 pounds in 1971, a decrease of 139,557 pounds from the previous year. Statistics Canada reports 1971 exports at 152,900 pounds, which compares with 174,100 pounds exported in 1970. World production and consumption statistics are not available.

Domestic industry

Chromasco Corporation Limited produces high-purity calcium and other alkaline earth metals at its Haley, Ontario smelter. Commercial grades are obtained by heating, under vacuum, charges of briquettes made from powdered lime and commercially pure aluminum in chrome-nickel steel retorts. The company purchases its supply of high-purity powdered lime. At a temperature of about 1170°C, calcium vaporizes and the calcium product is collected on a water-cooled con-

Table 1. Canadian calcium production and exports, 1970-71

	1970		1971^p	
	(pounds)	($)	(pounds)	($)
Production (metal)[1]	443,557	374,476	304,000	282,000
Exports (metal)				
Israel	–	–	55,100	77,000
Britain	11,500	21,000	9,400	17,000
The People's Republic of China	–	–	22,000	16,000
Belgium & Luxembourg	22,000	13,000	22,000	9,000
West Germany	5,000	6,000	6,600	9,000
Japan	4,400	4,000	6,600	6,000
United States	129,900	120,000	31,200	3,000
Other countries	1,300	1,000	–	–
Total	174,100	165,000	152,900	137,000

Source: Statistics Canada.
[1]Shipments of calcium metal, and calcium metal used in production of calcium alloys.
^{p}Preliminary. – Nil.

Table 2. Canadian calcium production and exports, 1962-71

	Production[1]	Exports
	(lb)	(lb)
1962	123,511	124,100
1963	98,673	92,100
1964	138,357	130,800
1965	159,434	148,300
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
1971p	304,000	152,900

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

denser at the end of the retort. The initial product, referred to as "crown", assays about 98 per cent calcium with small amounts of magnesium and nitrogen. A subsequent refining operation yields grades of higher purity. Chromasco makes four main grades of calcium: Grade 1 – chemical standard, 99.9 per cent calcium and minor amounts of other elements; Grade 2 – nuclear quality, 99.5 per cent calcium or 99.9 per cent calcium plus magnesium; Grade 3 – commercial grade (crown), 98 to 99 per cent calcium, 0.5 to 1.5 per cent magnesium, 1 per cent nitrogen maximum, 0.35 per cent aluminum maximum; Grade 4 – nominally 95 per cent calcium. Grades 1 and 2 contain low values in impurities, the maximum being 0.004 per cent manganese, 0.005 per cent iron, 0.025 per cent nitrogen and 0.010 per cent aluminum. Elements such as nickel, lithium, boron, sodium and cadmium are extremely minor impurities.

Magnesium metal is the principal product at the Haley reduction plant. Other products from the Haley operation, in addition to magnesium and calcium metals, include calcium and magnesium alloys and barium and strontium metals.

Uses

The major applications of calcium are: as a powerful reducing agent for separating several of the less common metals, such as titanium, zirconium, vanadium, thorium, niobium and uranium, from their oxides; as an additive to form alloys with aluminum, silicon, magnesium, lead and lithium; as an agent to remove sulphur, phosphorous and oxygen in the steel and ferrous alloys industry; as a debismuthizer for lead; as a reducing and dehydrating agent in the chemical industry. Calcium hydride, prepared from high-purity calcium metal, is a source of portable hydrogen for meteorological balloons, as well as being an effective reducing compound for several metal oxides. Alloys of calcium and silicon, and calcium, silicon and magnesium are widely used in the steel industry to control grain size, inhibit carbide formation, improve ductility and reduce internal flaws. Calcium is also used in orthocalcium compounds for special lubricants, corrosion inhibitors and detergents.

Prices

United States calcium prices according to Metals Week, December 20, 1971

	(¢ per lb)
Calcium metal, ton lots, full crowns	95
Calcium alloys, fob shipping point, freight equalized to nearest main producer, carload lots	
Calsibar, 15% Ca, 15% Ba, 60% Si	24.75
Calcium silicon, 32% Ca	24.75
Calcium-manganese silicon	38.5

Tariffs

Canada

Item No.		Most Favoured Nation
		(% ad val.)
92805-1	Calcium metal	15

United States

Item No.		
632.16	Calcium metal, unwrought	
	On and after Jan. 1, 1970	10
	On and after Jan. 1, 1971	9
	On and after Jan. 1, 1972	7.5
633.00	Calcium metal, wrought	
	On and after Jan 1, 1970	12.5
	On and after Jan 1, 1971	10.5
	On and after Jan 1, 1972	9

Sources: The Custom Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa. Tariff Schedules of the United States (Annotated, 1971) T.C. Publication 344

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.

There are three basic types of portland cement used in Canada–Normal Portland, High Early Strength Portland and Sulphate-Resisting Portland–all of which are covered in specifications under CSA Standard A5 – 1971 (Canadian Standards Association). Modified and low-heat cements, designed for mass concrete use such as in dam construction, are manufactured by several cement-producing companies in Canada. Masonry cement is a mixture of portland cement, finely ground, high-calcium limestone (35 to 65 per cent by weight) and a plasticizer. It is recommended that masonry cement produced in Canada conform to the CSA Standard A8 – 1970. This type of cement is sold as well under the following names–Mortar Cement, Mason's Cement, Brick Cement and Mortar Mix.

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

Cement has little use alone but when combined with water, sand, gravel, crushed stone or other aggregates in proper proportions, it 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 such as dams or can be used in the form of delicate precast panels or heavy prestressed columns and beams in building construction.

Summary, 1971

Cement is one of a number of industrial mineral commodities produced in Canada in direct support of the construction industry. The value of construction in Canada in 1971 was $15.6 billion, an increase of $0.4 billion from estimates made at the beginning of the year. Work stoppages again had a severe effect on construction spending but, as mortgage money was made more available during the latter part of the year, much needed residential construction prospered after experiencing some early hesitancy. The price index for concrete products rose about 7.7 per cent during the year, while the average weekly wage in the construction industry rose about 12 per cent over the same period. As the volume of construction tends to lessen per unit of expenditure, advances in construction techniques and equipment tend to improve the efficiency of an industry that is subject to many outside influences over which it has little or no control. It is estimated that the physical volume increase in construction was in the order of 7 per cent.

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

Table 1. Canada, cement production and trade, 1970-71

	1970		1971p	
	(short tons)	($)	(short tons)	($)
Production[1]				
By province				
Ontario	3,142,511	58,481,550	3,683,000	72,187,000
Quebec	2,237,198	39,536,174	2,671,000	47,277,000
British Columbia	601,803	13,210,848	957,000	22,968,000
Alberta	878,307	19,735,320	1,004,000	22,088,000
Manitoba	407,396	9,778,540	516,000	12,384,000
Saskatchewan	151,997	4,578,829	191,000	6,207,000
Nova Scotia	..	4,699,928	..	4,818,000
New Brunswick	..	3,296,573	..	3,811,000
Newfoundland	..	2,875,978	..	2,478,000
Total	7,945,915	156,193,740	9,534,000	194,218,000
By type				
Portland	7,685,837	150,559,909	9,210,000e	
Masonry[2]	260,078	5,633,831	324,000e	
Total	7,945,915	156,193,740	9,534,000	194,218,000
Exports				
Portland cement				
United States	566,499	11,250,000	885,631	15,672,000
Other countries	22	1,000	2,214	59,000
Total	566,521	11,251,000	887,845	15,731,000
Cement and concrete basic products				
United States		7,217,000		9,688,000
Other countries		251,000		91,000
Total		7,468,000		9,779,000
Imports				
Portland cement, white				
United States	12,856	586,000	14,608	680,000
Belgium and Luxembourg	4,029	114,000	4,548	130,000
Japan	5,635	149,000	2,822	68,000
Britain	171	5,000	100	4,000
Total	22,691	854,000	22,078	882,000
Cement, n.e.s.[3]				
United States	64,753	2,155,000	21,514	778,000
Britain	7,406	327,000	10,215	426,000
West Germany	1,818	131,000	1,179	115,000
France	519	17,000	887	28,000
Other countries	4	1,000	–	–
Total	74,500	2,631,000	33,795	1,347,000
Total cement imports	97,191	3,485,000	55,873	2,229,000
Refractory cement and mortars				
United States		1,654,000		1,840,000
Ireland		409,000		713,000
Britain		46,000		19,000
West Germany		31,000		11,000
Other countries		29,000		29,000
Total		2,169,000		2,612,000

Table 1 (Cont'd)

	1970		1971p	
	(short tons)	($)	(short tons)	($)
Cement and concrete basic products n.e.s.				
United States		231,000		254,000
Britain		2,000		78,000
West Germany		6,000		12,000
Belgium and Luxembourg		–		1,000
Other countries		2,000		–
Total		241,000		345,000
Cement clinker				
United States	13,831	353,000	11,937	290,000

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; n.e.s. Not elsewhere specified; . . Not available; – Nil; e Estimated.

Markets for cement tend to be regional because transportation costs represent a large part of the laid-down price to the consumer and only rarely, in the case of special cements, are shipments made beyond normal distribution boundaries. Production, therefore, is determined by the regional construction activity and forecast and in 1971 presented a reversal of that indicated during 1970 in that seven of the nine provinces in which cement is produced showed increased output while only two showed a decrease. After some adjustment of available data, current production capacity appears to be 14.7 million tons a year (see Table 3) exclusive of three plants which only grind clinker and still including some capacity which could be reactivated only at considerable expense. With production at 9,534,000 tons, the industry's capacity utilization was 65 per cent for the year.

There was no major increase in production capacity in 1971; 10 companies continued to operate 24 plants with a total of 56 kilns available for production. However, a number of plant expansions will be made during the period 1972 to 1975. Independent Cement Inc. will put a fourth kiln on stream during 1972 which will increase its plant capacity at Joliette, Quebec by approximately 220,000 tpy. Canada Cement Lafarge Ltd. is constructing a new plant at Bath, Ontario which will have a capacity of 1.1 million tpy and will cost about $50 million by the time it is operative in 1973. Canada Cement Lafarge's Exshaw plant will undergo extensive change by 1975 with the removal of two older kilns and the addition of one new kiln which will result in a net increase in capacity to approximately 700,000 tpy. Both Lake Ontario Cement Limited and St. Marys Cement Limited have indicated they intend to increase the capacities of their plants at Picton and Bowmanville respectively but neither company has announced the date, amount, or cost of the proposed expansions.

Table 2. Canada, cement production, trade and consumption, 1962-71p

(short tons)

	Production[1]	Exports[2]	Imports[2]	Apparent Consumption[3]
1962	6,878,729	219,164	26,525	6,686,090
1963	7,013,662	272,803	31,579	6,772,438
1964	7,847,384	297,669	32,680	7,582,395
1965	8,427,702	334,887	37,619	8,130,434
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
1971p	9,534,000	887,845	55,873	8,702,028

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

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 5.3 per cent of Canadian cement production capacity in a region having about 9 per cent of total population.

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 The Flintkote Company of Canada Limited, which quarries gypsum at Flat Bay, about 63 miles south of Corner Brook. Shipments of grey, portland cement are made by rail and by sea mostly to provincial markets. Production is directly dependent upon construction activity. The values of building permits issued and of heavy construction awards were reduced in Newfoundland during 1971. It is unlikely that production of cement will increase greatly in the near future.

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. During 1970 the value of Nova Scotia cement production decreased slightly as the number of housing starts and the value of building permits issued were lower than in the previous year. Heavy construction awards were increased in value over the same period.

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, has a capacity of 350,000 tons a year and ships portland cement in bulk or in bags. Shipments in 1971 were slightly greater than in 1970. As in Nova Scotia, both the number of housing starts and the value of building permits issued were lower than in 1970, while heavy construction awards were greater in value.

Quebec. In the Province of Quebec, five companies operate a total of seven cement manufacturing plants. Regionally, the companies producing cement in Quebec province compete for the construction markets in the Quebec and Montreal areas. These markets have been recovering from the post Expo '67 slump and have increased substantially over last year's level. Total cement production in Quebec was nearly half a million tons greater than in 1970 while the industry operated at an average of 54 per cent of recognized rated capacity.

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 and ships to distribution warehouses in the Atlantic provinces and in areas bordering the Great Lakes as well as to local consumers. The plant capacity, at 1.4 million tons a year, is second only to that of St. Lawrence Cement Company's Clarkson, Ontario plant that has a capacity of 1.75 million tons. Canada Cement Lafarge's Hull operation is on the site where cement was first produced in Canada. From this location, areas of the Ottawa Valley are served.

Miron Company Ltd., with the second largest cement-producing capacity in the Montreal area, operates a dry process plant at St. Michael. The company also supplies concrete and other building materials to the construction industry and maintains a contracting division.

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 by truck and rail. Finished products include normal portland cement, medium heat of hydration cement, high early strength cement, low heat of hydration cement and masonry cement. Shipments are made in bulk or in bags by truck and by rail.

During 1969 Lafarge Canada Ltd. (formerly Lafarge Cement of North America Ltd.) of Vancouver, British Columbia, acquired the cement manufacturing plant of Lafarge Cement Quebec Ltd., at St. Constant, 18 miles south of Montreal. The plant, now part of the Canada Cement Lafarge group, has a capacity of 525,000 tpy with current plans to add a new kiln of 500,000 tpy capacity by 1974. The plant is modern, technically efficient and could conceivably replace some of the capacity of Canada Cement's older Montreal East plant.

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, was scheduled to start up in 1970 and in 1972 a fourth kiln of similar design will be operative. This company has pursued an aggressive sales campaign and has captured a major share of the Montreal area markets.

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.

The value of building permits issued during 1971 in Quebec was much higher than in 1970 and the number of dwelling starts also showed an increase.

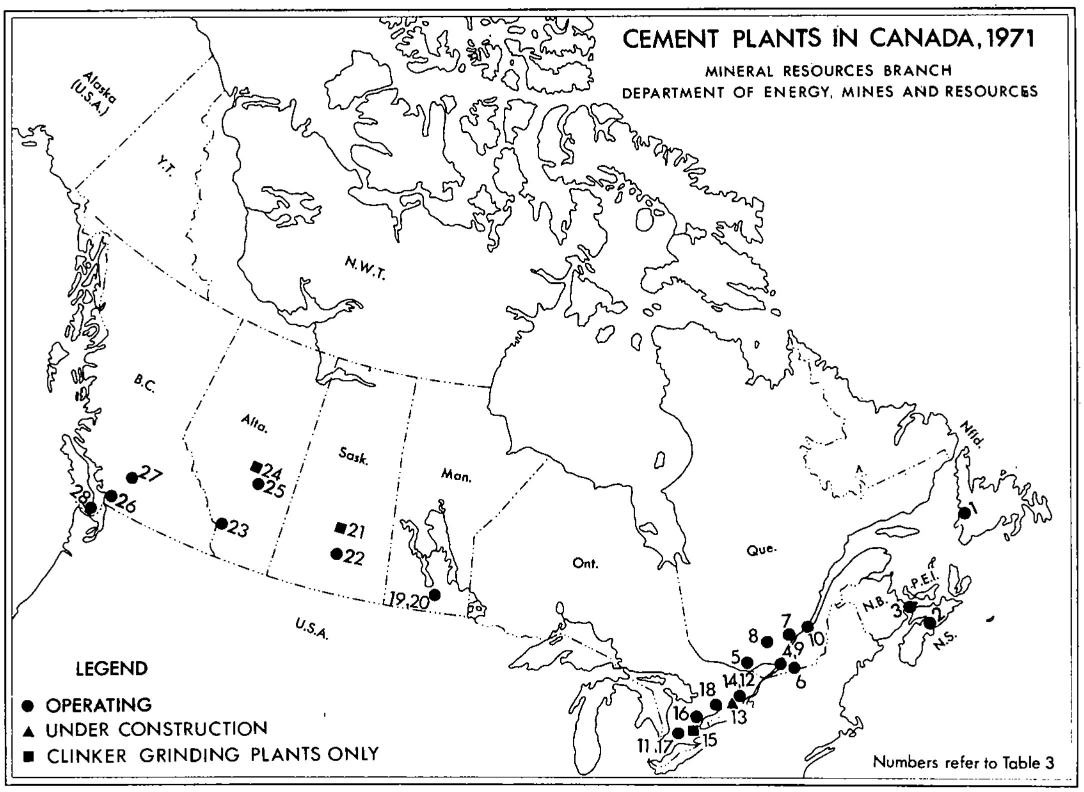
Quebec, with nearly 30 per cent of the nation's population has 34 per cent of Canadian cement producing capacity.

Ontario. Four companies operate a total of six cement manufacturing plants and one clinker grinding plant in the Ontario region, serving industrial and urban

Table 3. Cement plants—approximate annual capacities, 1971

Company	Plant Location	Process	(short tons)
Atlantic region			
1. North Star Cement Limited	Corner Brook, Newfoundland	dry	175,000
2. Canada Cement Lafarge Ltd.	Brookfield, N.S.	dry	262,000
3. Canada Cement Lafarge Ltd.	Havelock, N.B.	dry	350,000
Total Atlantic region			787,000
Quebec			
4. Canada Cement Lafarge Ltd.	Montreal	wet	1,400,000[1]
5. Canada Cement Lafarge Ltd.	Hull	wet	210,000
6. Canada Cement Lafarge Ltd.	St. Constant	dry	525,000[2]
7. Ciment Quebec Inc.	St. Basile	wet	380,000
8. Independent Cement Inc.	Joliette	dry	656,000[3]
9. Miron Company Ltd.	St. Michel	dry	1,050,000
10. St. Lawrence Cement Company	Villeneuve	wet	787,500
Total Quebec region			5,008,500
Ontario			
11. Canada Cement Lafarge Ltd.	Woodstock	wet	595,000
12. Canada Cement Lafarge Ltd.	Belleville	wet	770,000
13. Canada Cement Lafarge Ltd.	Bath	dry	1,100,000[4]
14. Lake Ontario Cement Limited	Picton	dry	875,000[5]
15. Medusa Products Company of Canada, Limited	Paris	grinding only	
16. St. Lawrence Cement Company	Clarkson	wet/*dry*	1,750,000[5]
17. St. Marys Cement Limited	St. Mary's	wet	743,000
18. St. Marys Cement Limited	Bowmanville	wet	350,000[5]
Total Ontario region			5,083,000
Manitoba			
19. Canada Cement Lafarge Ltd.	Fort Whyte	wet	630,000
20. Inland Cement Industries Limited	Winnipeg	wet	350,000
Saskatchewan			
21. Canada Cement Lafarge Ltd.	Floral	grinding only	
22. Inland Cement Industries Limited	Regina	dry	227,500
Alberta			
23. Canada Cement Lafarge Ltd.	Exshaw	wet	543,000[6]
24. Canada Cement Lafarge Ltd.	Edmonton	grinding only	
25. Inland Cement Industries Limited	Edmonton	wet	577,500
Total Prairie region			2,328,000
British Columbia			
26. Canada Cement Lafarge Ltd.	Lulu Island	wet	612,500
27. Canada Cement Lafarge Ltd.	Kamloops	dry	210,000
28. Ocean Cement Limited	Bamberton	wet	700,000
Total British Columbia region			1,522,500
Total capacity (56 kilns)			14,729,000

Source: Published data and company communication. [1]To be phased out. [2]Capacity to be doubled by 1974. [3]Capacity to be increased by approximately 220,000 tpy during 1972. [4]Not included in total. Under construction. Scheduled for 1973. [5]Capacities to be increased by as yet unrevealed amounts by 1973. [6]Capacity to be increased to 700,000 tpy by 1975.



growth areas in southern Ontario and shipping to points in Quebec and northern Ontario as well as exporting to the United States.

The industrialized and population-intense region surrounding Lake Ontario and Lake Erie continues to grow and in so doing provides markets for cement in

Table 4. Canada, cement plants, kilns, production and capacity, 1965-1971

	Number of Plants	Number of Kilns	Approximate Annual Capacity	Production	Capacity Utilization
			(tons)	(tons)	(%)
1971	24	56	14,729,000[1]	9,534,000	65
1970	24	56	14,729,000[1]	7,945,915	54
1969	23	54	14,500,000[1]	8,250,032	57
1968	23	54	14,500,000[1]	8,165,805	55
1967	22	53	12,655,000	7,994,954	62
1966	23	54	12,850,000	8,930,552	70
1965	21	52	11,770,000	8,427,702	72

Source: Data supplied by companies to Mineral Resources Branch.
[1] Adjusted.

Table 5. Canada, destination of domestic cement shipments[1], 1971

	(short tons)
Ontario	3,489,619
Quebec	1,899,914
Manitoba, Saskatchewan, Alberta and British Columbia	2,291,964
Newfoundland, Prince Edward Island, Nova Scotia and New Brunswick	495,162
Yukon and Northwest Territories	12,292
Canada, total	8,188,951
Exports	900,719
Total shipments	9,089,670

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

many engineering, commercial, industrial and residential building projects, all of which were greater in 1971 than in the previous year. The Ontario cement producers represent about 34 per cent of total production capacity in a region occupied by about 36 per cent of the total Canadian population. The industry operated at just over 70 per cent of capacity in 1971 and steady growth is indicated by the announced intentions to bring on stream an estimated additional 1.7 million tons a year of capacity in the next few years.

Lake Ontario Cement Limited is Canada's largest cement exporter. The plant is located at Picton where favourable raw materials are situated adjacent to deep water, permitting comparatively inexpensive bulk shipments to be made to Great Lakes and St. Lawrence Seaway ports. Shipments, also made by truck and by rail to domestic markets, were at an all-time high in 1971 and prompted the company to investigate the feasibility of plant expansion to meet the expected growth in demand for cement and concrete products.

The Belleville plant of Canada Cement Lafarge Ltd. is one of the original operations grouped to form the Canada Cement Company in 1909. Many equipment changes have been made over the years and the present three-kiln, wet process is capable of producing about 770,000 tons of cement a year. Subsequent to the company's announcement that a new 1.1 million tons a year plant will be constructed at Bath, Ontario by 1973, the company declared its intention to phase out the Belleville plant by the end of September, 1973. Located on deep water, the plant is served by ship as well as by rail and truck haulage.

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 portland cement.

St. Lawrence Cement Company constructed 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 and it features the largest suspension preheater kiln in North America and an Aerofall mill 27 feet in diameter by 8 feet in length, rated at 400 tons an hour of 8-inch stone. The company is to install what will be the largest mill in the world, 18 feet in diameter by 72 feet in length. A gearless drive system will be used in which the mill itself will be the rotor in a 32 foot diameter stator as part of an 8,700 hp synchronous motor, all designed by Aerofall Mills and Canadian General Electric Company Limited. Limestone for the plant is brought in by boat from Ogden Point, 100 miles east of Toronto on the north shore of Lake Ontario. 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.

St. Marys Cement Limited operates two plants in Ontario. The original plant at St. Mary's was constructed in 1912 to serve the Toronto area. It has been expanded and modernized over the years and remains a major producer capable of turning out about 750,000 tons a year. A new and highly automated plant was built at Bowmanville during 1967 and 1968. First shipments were made in January 1969. The plant is favourably located with respect to the major marketing area of metropolitan Toronto and is capable of producing 350,000 tons a year from raw material at the site. Plant expansion is anticipated. Shipments are made by truck and by rail.

Medusa Products Company of Canada, Limited, of Paris, Ontario, grinds a white clinker imported from the Medusa plant at York, Pennylvania. 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 16 per cent of Canadian cement-producing capacity exclusive of the grinding plants and during 1971 produced at approximately 70 per cent of that capacity. In general the construction industry improved during the year from what had been a relatively poor 1970.

Canada Cement Lafarge Ltd. operates a 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, gypsum is purchased from Gypsumville, 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. The present facilities are capable of producing up to 543,000 tons of cement a year from raw materials obtained locally. Finished cement is shipped by rail and truck to consumers in eastern British Columbia, 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. Clinker for the Floral plant currently is obtained from Fort Whyte.

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 is the most recent addition to the company's facilities, having gone on stream in 1965 to increase the company's total production capacity to over 1 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 is part of a total, 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 central British Columbia is served by Inland's facilities.

Pacific region. Construction in the British Columbia area flourished during 1971 with prospects of greater developments during the next few years. This upward swing was reflected in cement production from each of the three plants which represent in total 10 per cent of the nation's productive capacity. The industry operated at 60 per cent efficiency.

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 612,000 tons a year. A new plant with a capacity of over 210,000 tons a year began production in 1970 at Kamloops, British Columbia.

Ocean Cement & Supplies Ltd. quarries limestone at Bamberton on Vancouver Island for cement manufacture and for use as an aggregate. The cement plant has a capacity of about 700,000 tons a year.

In December, 1971, Genstar Limited announced that agreement had been reached with Associated International Cement Ltd. (A.I.C.), a wholly-owned subsidiary of Associated Portland Cement Manufacturers Ltd. of London, England, for the purchase of A.I.C.'s shares of Ocean Cement & Supplies Ltd. The block represents 51.5% of Ocean Cement's outstanding shares. Inland Cement Industries Limited, with plants in Winnipeg, Regina and Edmonton, is operated as a division of Genstar and such a take-over will leave the cement industry west of Manitoba (eight plants) the responsibility of two companies.

Markets and trade

Cement markets are regional in scope and are centred in developing or growing urban areas where construction activity is concentrated, or in areas where mining or heavy engineering construction projects are being performed. The market area influenced by a given cement producing plant is dependent 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. Some countries do, however, 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 are generally much smaller than for portland cement.

Cement from plants in the United States and Canada is traded between the two countries where competition and tariffs permit, Canada being a net exporter in this regard. Canadian market areas are reflected in the distribution of shipments from Canadian producers, shown in Table 5.

Although cement is used mainly in the construction industy, significant amounts are used in the mining industry to consolidate backfill where mining methods dictate. Amounts so used have grown 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 National Research Council's Industrial Research Assistance Program.

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

Commodity	1969	1970
	(short tons)	
Shale	450,359	838,157
Limestone	10,959,491	11,892,697
Gypsum	372,319	352,788
Sand	292,103	218,519
Clay	1,104,137	1,075,864
Iron oxide	75,696	80,987

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

The use of a gypsum-free portland cement in a new patented process for the production of cold-bonded iron ore pellets offers an interesting market possibility.

Outlook

The Canadian cement industry is highly competitive in a market that can accept only a definite and limited amount of its product. New plants are being built and existing ones are being expanded utilizing modern equipment and techniques of manufacture and choosing new plant locations suitably situated with respect to both resource material and markets. The expense of adapting older facilities to meet newly imposed environmental control regulations can contribute to a decision in favour of a new plant, and has, in the United States, forced a number of plant closures.

Company mergers, 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.

Construction in Canada will continue to show an annual increase in value and cement producers will have to compete with all other building materials to obtain their share of the construction dollar. In this respect, not only practical research in the use of cement-concrete is 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. The Portland Cement Association is an industry-supported, non-profit 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.

Specifications

Portland cement used in Canada should conform with 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 and not covered by the CSA standards generally meet the appropriate specifications of the American Society for Testing and Materials (ASTM).

Table 7. Planned capacity increases (by kiln additions) – cement plants

Company	Location	Net Increase	Expected Completion Date	Approximate Cost
		(tons/year)		($)
Quebec				
Canada Cement Lafarge Ltd.	St. Constant	500,000	1974	30 million
Independent Cement Inc.	Joliette	220,000	1972	. .
Ontario				
Canada Cement Lafarge Ltd.	Bath	1,100,000 (new)	1973	50 million
Lake Ontario Cement Limited	Picton	250,000[e]		. .
St. Marys Cement Limited	Bowmanville	350,000[e]		. .
Alberta				
Canada Cement Lafarge Ltd.	Exshaw	200,000	1975	30 million

[e]Estimated; . .Not available.

Table 8. Cement, world production and capacity

Country	Estimated Annual Production Capacity 1971	Production 1970	Estimated Production 1971
	(thousands of short tons)		
United States (incl. Puerto Rico)	83,700	76,465	81,400
Canada (shipments)	14,700	7,946	9,500
Other North America (except Cuba)	13,200	11,315	12,000
Total, North America	111,600	95,726	102,900
South America	28,200	25,151	26,300
Europe (free)	218,000	196,214	206,800
Asia (free)	132,000	118,948	126,000
Africa	20,700	19,325	20,700
Oceania	7,100	6,501	6,600
Communist countries (except Yugoslavia)	180,000	168,310	178,600
World total	697,600	629,725	667,900

Data Source: U.S. Bureau of Mines, Division of Non-Metallic Minerals.

World review

Cement-producing facilities on six continents were taxed heavily during 1971 according to available data on total world cement production. Capacity utilization ranged from an estimated 92 per cent to 100 per cent and in total averaged 95 per cent. This would indicate that additional production capacity is about to come on stream in many countries in all areas of the world. The isolated items noted following are indicative of trends in the regions noted but in no way represent a total coverage. Because of the direct relationship of cement-concrete-construction, the production and, more particularly, the consumption of cement can be monitored as an indication of a country's rate of development. In 1971 world production of cement was estimated to be 667,900,000 short tons, an increase of 6 per cent over that of 1970.

Europe. Italy maintained its rather spectacular rate of increase in cement production during 1970 to retain the position of second largest producer in Europe and now has a capacity of over 37 million tons a year.

Societe Ciments Lafarge is adding a 150,000 tpy facility at Dunkirk, France, scheduled for 1974.

Greek cement production in 1970 totalled 5.4 million tons, a slight increase over the 5.3 million-ton output in 1969. Local consumption was 5.1 million tons, as compared to 4.7 million tons in 1969. Exports declined during the year as a result of increased local demand. The country's cement industries have stepped up their expansion programs, which are expected to raise annual production to 8.8 million tons.

Table 9. World production of cement, 1960 and 1970

	1960	1970	Production Increase
	(thousand short tons)		(%)
U.S.S.R.	50,177	104,988	109
United States	62,816	76,464	22
Japan	24,844	63,043	154
West Germany	27,453	42,249	54
Italy	17,652	36,469	107
France	15,623	31,971	105
Britain	14,878	18,797	26
Spain	6,319	18,228	188
India	8,637	15,384	78
Poland	7,266	13,426	85
China	14,881	11,023	-26
Canada	5,787	7,946	37
Czechoslovakia	5,568	8,162	47
Other countries	86,563	169,834	96
Total	348,464	617,984	77

Sources: Statistics Canada; U.S. Bureau of Mines *Minerals Yearbook*, 1962 for 1960; United Nations Monthly Bulletin of Statistics 1972; U.S. Bureau of Mines: "The mineral Industry of Mainland China" (1970) Pre-print); *Commodity Year Book, 1971*- Commodity Research Bureau Inc.

Table 10. World cement production, per capita, 1960 and 1970

	1960	1970	Increase
	(lb)	(lb)	(%)
Belgium	1,056	1,533	45
West Germany	1,031	1,422	38
Italy	711	1,359	91
France	683	1,259	84
Japan	533	1,220	129
Spain	417	1,079	159
Czechoslovakia	815	1,128	38
Canada	646	742	15
U.S.S.R.	468	865	85
U.S.	695	746	7

Asia. Major Japanese cement producers are expanding or adding production facilities to meet an anticipated demand of 100 million tpy in 1975. This growth, which represents a 25 per cent increase over the previous forecasts, is principally due to a government decision to step up public works.

During 1970, India's public sector Cement Corp. of India Ltd. (CCIL) maintained an effective supply-demand balance. Various expansion programs to increase production capacity to 21.2 million tons per year by 1973 are currently underway, although some sources believe demand will be only about 15 million tons at that time.

North America. 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 the demand. The cement industry had then 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 16 per cent of world cement production comes from North American countries with the United States contributing nearly 80 per cent of the total and Canada and Mexico following in that order. Numerous plant changes and additions have been announced throughout the industry in North America. Virtually all plants are undergoing some degree of modernization and improvement of dust collecting facilities in face of new or anticipated pollution control standards and a number of plants in the United States have cited those measures as reason for closure. Canada enjoys a surplus capacity at this stage and with about 2.5 million tons a year additional capacity planned, could be in a favourable export position during the next few years.

Table 11. Canada—production of concrete products

	1970	1971
Concrete bricks (no.)	80,300,328ʳ	109,480,448
Concrete blocks (except chimney blocks)		
Gravel (no.)	142,990,493ʳ	171,919,906
Other (no.)	37,204,691	35,288,949
Concrete drain pipe, sewer pipe, water pipe and culvert tile (st)	1,075,706	1,508,520
Concrete, ready mix (cu yd)	12,821,761	15,047,226

Source: Statistics Canada.
ʳRevised.

The United States will, in 1972, adopt the hundredweight as a standard sales and marketing unit and cement production will be noted in terms of short tons, doing away with the 376-pound barrel unit.

Cementos Mexicanos, S.A., is one of Mexico's leading producers, with an annual output of more than 465,000 tons of portland and white cement at its main plant in Monterrey, and branch facilities at Torreón, in Coahuila, and Ciudad Valles at San Luis Potosí, each producing about 200,000 tons a year. A subsidiary firm, Cementos Maya, S.A., located at Merida, in Yucatán, installed a new plant which was expected to start producing 200,000 tons a year during 1971. An affiliated firm located in Monterrey, Cementos del Norte, S.A., owned jointly with the Fundidora group of companies, produces about 150,000 tons of slag and portland cement a year. In addition, work is underway to double the production capacity of the main plant of Cementos Mexicanos in Monterrey and the branch in Torreón.

South America. The Government of Brazil gave final approval for a cement plant project to be constructed about 180 kilometres south of São Paulo by International Telephone and Telegraph Corporation (ITT) of the United States. The plant will have a production capacity of 2,650 tons a day of dry-processed portland cement. Operations are scheduled tentatively to start in about 2 years.

The Brazilian cement industry expects to produce 21 million tons a year in 1975, requiring investments of more than $500 million. Current production is 9 million tpy. Empresa Cemento Chimborazo, C.A. has contracted with Allis-Chalmers for a dry process cement plant and distribution system, to be built at Quito, Ecuador. The 55 tons a day plant will more than triple the capacity of the firm's present plant at San Juan Chico.

The production capacity of Argentina's cement industry is estimated at 675,000 tons a month, but output recently has been running about 70 per cent of capacity. During January-May 1971, production totalled 2.3 million tons compared with 2.0 million tons in the corresponding period of 1970.

Africa. Output from Angola's two cement producers increased 17 per cent during 1970, to about 500,000 tons. The Luanda plant of Companhia de Cimento SECIL do Ultramar is expected to attain a capacity of 660,000 tons a year during 1971. The other producer, Companhia dos Cimentos de Angola, has an annual capacity of 100,000 tons. Exports during the year totalled only 82,000 tons, representing an increase of 34 per cent over 1969 shipments. The principal buyers were Nigeria and Gabon, besides other Portuguese territories.

Oceania. Production of cement in Oceania is mostly from Australia where 16 plants have a total capacity of over 5 million metric tons. Australia's consumption of cement is increasing at about 6 per cent a year and is close to, if not above, the United States and Canada on a per capita basis.

Prices

The average value of all Canadian shipments in 1971 was $20.37 a ton based on 1971 preliminary data and compared with $19.66 a ton in 1970. Prices varied considerably across the country reflecting principally transportation costs for both raw material and for finished cement.

Tariffs

Canada

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

United States

Item No.		On and After Jan. 1, 1971	On and After Jan. 1, 1972
		(¢ per 100 lb incl. weight of container)	(¢ per 100 lb incl. weight of container)
511.11	White, nonstaining portland cement	1.5	1
511.14	Other cement and cement clinker	0.4	free
		(%)	(%)
511.21	Hydraulic cement concrete	1	free
511.25	Other concrete mixes	9	7.5

Sources: The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa. Tariff Schedules of the United States annotated (1971), T.C. Publication 344.

Chromium

D.D. BROWN

Canada's imports of chromium in ores and concentrates in 1971 were 32,716 tons (Cr content) valued at $2,829,000 compared with 30,445 tons valued at $2,331,000 in 1970. Imports of ferrochromium were 39,906 tons valued at $9,952,000 compared with 22,943 tons valued at $6,198,000 in 1970. Chromite consumption was 61,963 tons in 1970 and 68,484 tons in 1969. Canadian companies manufacturing chromite refractories as a primary product used 45,162 tons of chromite valued at $1.99 million in 1969.

Canada is not a producer of chromite ($FeOCr_2O_3$), the principal ore mineral of chromium. The 64 years 1886 to 1949 covered Canada's periods of recorded, small and intermittent production of chromite. Production was reported in 47 of those years and totalled 278,326 tons valued at $5,616,401. The Province of Quebec produced 272,252 tons of the total; 5,278 tons came from Ontario and 796 tons from British Columbia. The periods of highest annual production were 1915 to 1920 and 1941 to 1945 with highs of 36,725 tons in 1917 and 29,596 tons in 1943.

Chromium has wide and essential uses in the iron and steel industry. It is a principal constituent of stainless steel, is used in structural and tool steels, machinery parts, heating elements and in corrosion-resistant applications. Chromium in the form of its principal mineral chromite is used in refractories for metallurgical furnace and ladle linings. Chromium chemical products are used in making pigments, dyes and fungicides and in the electroplating and leather-tanning processes.

The additive alloy ferrochromium, commonly used to add chromium to iron and steel, is produced in Canada by Union Carbide Canada Limited. Union Carbide's manufacture of ferroalloys includes high-carbon ferrochrome, charge chrome and ferrochrome silicon. Suppliers of chromite and chromium additives other than Union Carbide include Chromium Mining & Smelting Corporation, Limited; Philipp Brothers (Canada) Ltd.; Metallurg (Canada) Ltd.; and Continental Ore Co. (Canada) Limited.

Consumers of chromium in Canada include Atlas Steels Division of Rio Algom Mines Limited; Colt Industries (Canada) Ltd.; Fahralloy Canada Limited; and The Steel Company of Canada, Limited. Among the manufacturers of chromite-bearing firebrick, cements and mortars are: Canadian Refractories Limited; General Refractories Company of Canada Limited; Kaiser Refractories Company Division of Kaiser Aluminum & Chemical Canada Limited; and Quigley Company of Canada Limited.

Table 1. Canada, chromium trade and consumption, 1970-71

	1970		1971p	
	(short tons)	($)	(short tons)	($)
Imports				
Chromium in ores and concentrates				
United States	13,226	1,127,000	15,581	1,331,000
U.S.S.R.	6,670	458,000	6,834	670,000
Cyprus	1,064	88,000	3,448	324,000
Philippines	7,616	514,000	2,856	204,000
Ireland	198	24,000	1,437	182,000
South Africa	–	–	2,560	118,000
Other countries	1,671	120,000	–	–
Total	30,445	2,331,000	32,716	2,829,000
Ferrochromium				
South Africa	13,349	2,909,000	32,177	6,729,000
Japan	110	31,000	4,199	1,733,000
United States	9,052	3,125,000	2,524	1,071,000
Sweden	101	23,000	422	197,000
Norway	331	110,000	445	165,000
France	–	–	110	50,000
West Germany	–	–	29	7,000
Total	22,943	6,198,000	39,906	9,952,000
Chromium sulphates, basic, for tanning				
United States	1,023	236,000	888	225,000
Japan	285	48,000	360	60,000
Britain	48	9,000	140	30,000
Total	1,356	293,000	1,388	315,000
Chromium oxides and hydroxides				
Japan	218	108,000	441	211,000
United States	175	128,000	171	122,000
Britain	74	41,000	76	59,000
West Germany	18	16,000	73	49,000
Belgium-Luxembourg	21	10,000	12	7,000
Netherlands	14	7,000	6	3,000
Other countries	11	6,000	–	–
Total	531	316,000	779	451,000
Chrome dyestuffs				
United States	17	45,000	48	73,000
West Germany	11	35,000	12	46,000
Switzerland	7	31,000	19	26,000
Britain	7	14,000	9	18,000
Japan	7	15,000	7	12,000
Netherlands	2	3,000	4	7,000
France	1	1,000	1	3,000
Italy	1	1,000	1	1,000
Other countries	3	3,000	–	–
Total	56	148,000	101	186,000
Consumption				
Chromite	61,963	. .	. .	. .

Source: Statistics Canada.
pPreliminary; – Nil; . . Not available.

Table 2. Canada, chromium trade and consumption, 1962-71^p

(short tons)

	Imports		Exports	Consumption[2]	
	Chromite[1]	Ferro-Chromium[2]	Ferro-Chromium[2]	Chromite	Ferro-chromium
1962	71,969	..	6,602	70,342	9,453
1963	49,654	..	2,910	56,016	9,662
1964	20,794	10,482	172	57,734	11,212
1965	35,408	15,336	205	69,105	12,903
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^p	32,716	39,906	..	..	..

Source: Statistics Canada.
[1]To 1963, gross weight; from 1964, chromium content; [2]Gross weight.
^{p}Preliminary; .. Not Available; – Nil.

Chromium production and trade

Estimated world mine production of chromite was 6.4 million tons in 1971 compared with 6.5 million tons in 1970. The U.S.S.R., Republic of South Africa, Philippines, Turkey and Rhodesia supplied most of the world's chromite. The United Nations embargo on chromium ore from Rhodesia ostensibly stopped supplies from that country to UN signatories; it was particularly effective in stopping supplies from Rhodesia to Canada and the United States. Since the introduction of the sanctions other producer nations have increased their prices for metallurgical chromite. The price of Russian chromite, per long ton, 54-56 per cent Cr_2O_3, 4:1 chrome-to-iron ratio, fob cars Atlantic ports was published at U.S. $36.50-40 in 1968, U.S. $45.20-49.20 in 1969, and U.S. $55.10-59.60 in 1970. In 1971 Russian prices to U.S. were $51.50-55 per metric ton fob Russian ports.

United States, the principal importer and consumer of chromite, relies on imported supplies. United States imports of chromite in 1971 were 1,298,886 tons and consumption was 1,086,229 tons compared with 1,405,527 tons imported and 1,402,538 tons consumed in 1970*. The metallurgical industry used 66 per cent of the 1971 United States consumption, the refractory industry 17 per cent, and the chemical industry 17 per cent. The largest supplier was the U.S.S.R. with 33 per cent, followed by South Africa 30 per cent, Turkey 18 per cent, Philippines 15 per cent and other countries 4 per cent.

During 1971 the United States General Services Administration sold 7,838 long dry tons of metallurgical-grade chrome ore and 29,348 short dry tons of refractory ore from stockpile.

*U.S. Bureau of mines, Mineral Industry Surveys, Feb. 24, 1972.

Table 3. World production of chromium ore, 1969-71

	1969	1970	1971^e
	(thousands of short tons)		
U.S.S.R.^{e}	1,874	1,929	1,929
Republic of South Africa	1,320	1,573	1,700
Philippines	518	635	560
Turkey	492	526	530
Rhodesia	400	400	400
Albania	360	500	
India	237	293	
Iran	100	132	
Finland	79	133	
Malagasy Republic	49	155	
Yugoslavia	43	45	1,252 (Albania to Brazil)
Greece	33	59	
Japan	33	12	
Pakistan	29	39	
Cyprus	26	36	
Sudan	24	29	
Brazil	18	31	
Total	5,635	6,527	6,371

Sources: U.S. Bureau of Mines, *Minerals Yearbook 1969;* for 1970, 1971 Commodity Data Summaries January 1972; author's estimate.
^{e}Estimated.

Chromium ore and the uses of chromium

Chromium is never found in the free uncombined state in natural occurrences and chromite is its only commercially important ore mineral. The theoretical composition of chromite is $FeOCr_2O_3$ with a chromic oxide (Cr_2O_3) content of 68 per cent, and 32 per cent of iron oxide (FeO). Chromite in ore occurrences is usually found as a combination of oxides of chromium and iron with varying amounts of magnesium and aluminum and has the general formula $(Fe,Mg)O(Cr,Al,Fe)_2O_3$. The better ores of chromite contain from 42 to 56 per cent Cr_2O_3 and 10 to 26 per cent FeO, with mixed amounts of magnesia and alumina; silica and calcium are also usually present.

The earliest development in the use of chromium was in the chemical field. Its use in the making of paint pigments started about 1800 in France and Germany and about 1816 in England. The use of chromium chemicals expanded during the next 25 years with their introduction into textile colouring and the tanning of leather. Chromite was used as a refractory for furnace linings in France in 1879, but it was not until 1900 to 1915 that chromium ore became metallurgically important. Since that time the uses of chromium have shown sustained important growth. Chromium ore is used in three principal industrial activities: the metallurgical, chiefly in the form of ferrochromium for addition to steel; the refractory, in making chemically neutral refractory bricks and furnace linings; the chemical, including the making of paint pigments and the chromium plating of metals.

Variations in chemical and physical properties are the basis for classifying chrome ores into three main groups: metallurgical, refractory and chemical grades. The consumption and chromic oxide (Cr_2O_3) content of the ores used by the metallurgical, refractory and chemical industries in the United States are given in Table 5.

Metallurgical chromite and ferrochromium. The better-grade metallurgical chromite ores are hard lumpy ores containing 48 per cent or more Cr_2O_3 and having a chromium to iron ratio (Cr:Fe) of three to one (3:1), or more. A high chromium to iron ratio is important to reduce losses in the submerged-arc electric smelting process commonly used in making ferrochromium.

Most of the chromite used by the metallurgical industry is converted to one of the several chromium ferroalloys. Some chromite is converted to chromium metal for use in special alloys and some chromite is added directly to steel. Chromite promotes hardenability and improves corrosion and wear resistance of iron and steel. It is a principal alloying constituent of stainless steels, which account for more than 65 per cent of the consumption of chromium ferroalloys used by the metallurgical industry.

Ferrochromium is commonly made by reducing chromite with coke in submerged-arc electric furnaces. A modern 35,000-kilowatt furnace produces 175 to 200 tons of ferrochromium a day. High-carbon (3 to 6 per cent C) ferrochromium (50 to 70 per cent Cr) is used to add chromium to medium- and high-carbon

Table 4. Consumption of chromite and tenor of ore used by primary consumer groups in the United States, 1963-70

	Metallurgical Industry		Refractory Industry		Chemical Industry		Total	
	Gross Weight	Average Cr_2O_3	Gross Weight	Average Cr_2O_3	Gross Weight	Average Cr_2O_3	Gross Weight	Average Cr_2O_3
	(thousands short tons)	(%)	(thousands short tons)	(%)	(thousands short tons)	(%)	(thousands short tons)	(%)
1963	632	48.7	368	34.6	187	45.1	1,187	43.8
1964	832	49.0	430	33.8	189	45.1	1,451	44.0
1965	907	49.8	460	34.7	217	45.0	1,584	44.8
1966	828	49.6	439	34.6	194	44.9	1,461	44.5
1967	866	49.7	310	34.0	179	45.2	1,355	45.5
1968	804	49.7	311	34.1	202	45.1	1,316	45.4
1969	898	49.1	302	35.0	211	45.1	1,411	45.5
1970	912	48.0	278	35.9	213	45.3	1,403	45.2

Source: Preprints from 1969 and 1970 *U.S. Bureau of Mines Minerals Yearbooks.*

steels in which both chromium and carbon are required. Low-carbon ferrochromium (60 to 73 per cent Cr) containing .010 to 2 per cent carbon, is used in producing stainless and heat- and corrosion-resistant steels with low carbon specifications. Other ferroalloys of chromium contain more carbon or silicon and some contain an oxidizing agent such as sodium nitrate to react exothermically when added to molten iron or steel.

Chromium content ranging from 16 to 26 per cent is used in the chromium-nickel and chromium-nickel-manganese types of stainless steel. Nickel-base chromium alloys are used in jet engines, turbine blades, heating elements and in handling equipment for hot or corrosive chemicals. Chromium is used in a variety of other alloy steels ranging in content from less than one per cent to as much as 35 per cent chromium.

Refractory-grade chromite. Chromite is used directly in refractories because of its high melting point, moderate thermal expansion and its resistant, chemically neutral nature. Processing by the refractory industry involves sizing, blending and the forming, curing and firing of the refractory shapes required. Chromite refractories are used extensively for the lining of metallurgical and glassmaking furnaces, hot-metal ladles and in lime kilns. Specifications for refractory-grade chromite are not as rigid as for metallurgical but mineral constituents are important in the making of good-quality refractory brick. The refractory industry uses chromite averaging about 35 per cent Cr_2O_3. The iron and silica content should not be over 12 and 6 per cent, respectively; chromic oxide (Cr_2O_3) and alumina (Al_2O_3) combined should be about 60 per cent. The ore should be hard and lumpy and about -10 mesh in size. Chromite fines are suitable for the manufacture of refractory brick cement and chrome-magnesite brick. Friable chromite ores (43 to 50 per cent Cr_2O_3) are being used principally in South Africa, to supply prepared chromite sands to the metallurgical industry for use in foundry moulds.

Chemical-grade chromite and chromium chemicals. Chromium chemicals are used in pigments, leather tanning, electroplating, fungicides and in a variety of chemical processes as catalysts and oxidants. Chromium plating of plastic parts for automobiles, appliances and home furnishings is a growing industrial use.

The chemical industry uses chromite averaging about 45 per cent Cr_2O_3; the chromium to iron ratio is usually about 1.6 to 1. Specifications are less rigid than for metallurgical grade. Friable ores and fines are acceptable but Cr_2O_3 content should not be less than 44 per cent, alumina (Al_2O_3) not more than 15 per cent, and not over 20 per cent total iron and 5 per cent silica.

The principal chromium chemicals derived from chromite are the chromates and dichromates of sodium. These salts are used to make other chromium compounds such as chromic oxide, chromic acid, tanning compounds and pigments.

The finely ground chrome ore is mixed with measured amounts of soda ash (Na_2CO_3) and lime (CaO) and the dry mixture is fed to a horizontal rotary roasting kiln. Modern kilns are typically from 7 to 9 feet in diameter and 60 to 180 feet in length. They are lined with refractories and fired with oil or powdered coal, using an excess of air. The temperature in the firing zone of the kiln reaches 1100° to 1150°C as the material passes through in 1 to 4 hours at a rate of 2 to 10 tons an hour depending on the kiln capacity. The cooled roasted product containing sodium chromate (Na_2CrO_4) is leached in filter boxes with water and a nearly saturated solution containing the soluble sodium chromate is recovered. The chromate solution is concentrated by evaporation to 40 or 45 per cent Na_2CrO_4 and is then treated with sulphuric acid or pressurized carbon dioxide to convert the sodium chromate to sodium dichromate in a solution containing 80 to 85 per cent hydrous sodium dichromate ($Na_2Cr_2O_7 2H_2O$). Cooling the solution to about 35°C produces crystals of sodium dichromate dihydrate. The sodium dichromate dihydrate is sold in technical and chemically pure grades, and as a 70 per cent solution.

Sodium chromate (Na_2CrO_4), also obtained from the leaching operation, is similarly cooled to cause crystallization of $Na_2CrO_4 4H_2O$ which may be sold as hydrous sodium chromate or redissolved and evaporated to dryness to produce anhydrous sodium chromate.

Chromium electroplating. Chromium is the plating material most familiar to the public, as the final finish on a great variety of consumer products. The process, unique in some respects, uses a solution of chromium trioxide (CrO_3) and a small amount of a catalyst sulphate, often sulphuric acid (H_2SO_4); in some processes various proprietary catalysts may be used. Electroplating with chromium became particularly successful following the discovery that polishing the metal base and then plating with a thin coat of nickel under the equally thin chromium gave excellent appearance and durability. In addition to its decorative uses, chromium plating is widely used for its hardness and bearing properties, generally in heavier deposits than those used for decoration or protection from discolouration.

An outstanding property of chromium plating is its extreme hardness. Expressed in Brinell numbers the hardness of nickel plate is about 300 while chromium is about 1000. An early use for hard chromium plate was on gauges. The plating improves resistance to wear, prevents seizing to the work and permits replating after excessive wear. The great hardness of chromium plating is particularly useful for the moving parts of machinery, automotive parts and drawing dies, and for the salvage and repair of worn steel parts of mechanical equipment.

Prices

Chrome prices published by Metals Week

	December 28 1970		December 20 1971	
	(U.S. \$)		(U.S. \$)	
Chrome ore per long ton, dry basis, subject to penalties if guarantees not met, fob cars Atlantic ports				
Transvaal 44% Cr_2O_3, no ratio	25-27		25-27	
Turkish 48% Cr_2O_3, 3:1 ratio	55-56		55-56	
Russian 54-56% Cr_2O_3 4:1 ratio, per metric ton in 1971	55.10-59.60		51.50-55.00 (fob Russian ports)	
Chromium metal				
Electrolytic, 99.8% fob shipping point, per lb	1.15		1.30	
Vacuum melting (pellet) per lb	1.25		1.37	
9 per cent C, per lb	1.56		1.56	
Aluminothermic, delivered per lb, 99.25%	1.15		1.15	
Ferrochrome per lb Cr content, fob shipping point	(¢)		(¢)	
High carbon 67-70% Cr, 5-6% C	28.7		26.7	
Charge chrome, 63-71% Cr, 3% Si max, 0.04% S, 4.5-6% C	25.0		23.0	
Imported charge chrome	22.5-23.5		21.0[n]	
Blocking chrome				
10-14% Si	27.6		27.6	
14-17% Si	28.6		28.6	
Chromsol, 57-62% Cr, 4-6% Mn, 1.5% Si, 6.5% C, per lb, alloy, fob shipping point	16.75		15.55	
HS chrome – 66	42.5		42.5	
Low carbon				
67-73% Cr, 0.025% C	39.5		39.5	
67-71% Cr, 0.05% C	38.0		38.0	
Simplex, 0.01% max C	39.5		39.5	
Simplex, 0.020% max C	38.0		38.0	
Imported low carbon				
delivered 0.05% C	37.0		35.75-36.0[n]	
0.025% C	38.0		37-37.5[n]	
	Cr	Si	Cr	Si
	(¢)	(¢)	(¢)	(¢)
Ferrochrome silicon, per lb Cr plus lb Si				
36/40, 0.05% C	26.25	16.0	26.25	16.0
40/43, 0.05% C	29.0	16.0	29.0	16.0
"L", 0.02% C	30.0	16.0	30.0	16.0

[n]Nominal.

Tariffs

Canada

Item No.		British Preferential	Most Favoured Nation	General
		(%)	(%)	(%)
32900-1	Chrome ore	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
37506-1	Ferrochrome	free	5	5
92821-1	Chromium oxides and hydroxides	10	15	25
	From July 15, 1971 to Jan. 31, 1973 with the exception of the following:	free		
	Chromic oxides	10	15	25
	Chromium trioxide	10	15	25
92838-8	Chromium potassium sulphate	free	free	10
92828-9	Chromium sulphate, basic	free	free	10

United States

Item No.		On and After Jan. 1, 1971	On and After Jan. 1, 1972
601.15	Chrome ore	free	
		(%)	(%)
632.18	Chromium metals, unwrought (duty on waste and scrap suspended)	6	5
633.00	Chromium metal, wrought	10.5	9
632.84	Chromium alloys, unwrought	10.5	9
	Ferrochromium		
607.30	Not containing over 3% by weight of carbon	5	4
607.31	Containing over 3% by weight of carbon	0.625 ¢ per lb on chromium content	
416.45	Chromic acid	7	6
422.92	Chromium carbide	7	6
531.21	Chrome brick	15	12.5
473.10	Chrome colours	6	5
420.98	Chromate and dichromate	1.05¢ per lb	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 (1971), TC Publication 344.

Clays and Clay Products

G.O. VAGT

Clays are secondary minerals, hydrous aluminum silicates, formed by the chemical weathering or alteration of aluminous minerals such as feldspar and mica. They are classified into three major groups based on detailed chemistry and structure: the kaolinite group, the montmorillonite group and the illite group. Clay deposits suitable for the manufacture of certain products may include nonclay minerals such as quartz, calcite, dolomite, feldspar, iron-bearing minerals and organic matter. The nonclay minerals may, or may not be deleterious, depending upon individual amounts present.

The commercial value of clays and of shales that are similar in composition to clays, depends mainly on their physical properties and location. Properties of prime importance are: plasticity, strength, shrinkage, vitrification range and refractoriness, fired colour, porosity and absorption.

Clay and shale occurrences

Common clay 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 and/or chloritic. The presence of iron usually results in a salmon or red fired colour. Their fusion points are low, usually well below pyrometric cone equivalent number 15 (PCE 15 – the pyrometric cones are a convenient method of relating temperature and time by a single value), which is defined by a temperature of approximately 1430°C and is considered to be the lower limit of the softening point for fire clays. Ordinarily, the common clays and shales are a heterogeneous mixture including clay minerals and various other minerals such as quartz, feldspar, mica, goethite, siderite, pyrite, carbonaceous material, gypsum, calcite, dolomite, hornblende and others, which act as fluxing impurities.

Suitable common clays and shales are utilized in the manufacture of heavy clay products such as common brick, facing brick, strucutral 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 fired strength and density will be adversely affected.

Most of the common surface clays are the result of severe glaciation. Such Pleistocene deposits are of interest to the ceramic industry and include stoneless marine and nonmarine sediments, reworked glacial till, interglacial clays and floodplain clays. These deposits are characterized by low melting temperatures. Some Tertiary and Cretaceous deposits that occur near the surface are of interest. An important characteristic of these older deposits is the wide range of refractoriness, or fusibility, depending on the locality and the nature of the formation.

The common shales, as opposed to the common clays, have been found to provide the best source of raw material for making brick. The principal shales useful to the ceramic industry are found in Cambrian, Ordovician and Carboniferous rocks in eastern Canada, and Jurassic, Cretaceous and Tertiary rocks in western Canada. In many instances these shales are more refractory than the Pleistocene clays; in some areas, particularly in western Canada, they are very refractory.

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 decompositional process, known as kaolinization, results in a hydrated aluminum silicate ($Al_2O_3 \cdot 2SiO_2 \cdot 2H_2O$) with the approximate percentage composition as follows: 40% Al_2O_3, 46% SiO_2 and 14% H_2O. In North America and in Europe the clay so formed is commonly termed "kaolin", whereas in Britain, the term used is "china clay".

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 with particles that vary in size from coarse to very fine. High proportions of substances such as mica, feldspar, magnetite, pyrite and colloidal iron have been observed. In the crude material the percentage of kaolinite frequently is small, making removal of impurities from Canadian kaolins difficult. Consequently, the principal Canadian consumers of ceramic-grade china clay import their requirements mainly from the United States and Britain.

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, floor tile, sanitaryware, dinnerware, pottery and electrical porcelain, nepheline syenite, silica, feldspar and talc are used as well.

Lower-quality kaolins in North America may be mined and more expensive processing may be justified as higher-quality kaolins become depleted. If this situation arises, the development of a few Canadian deposits may become more attractive, particularly if new processing techniques and equipment become available.

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 is 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 have been investigated in Manitoba. 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.

In recent years 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-Rémi-d'Amherst, Papineau County; Brebeuf, 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 but distance from markets and the difficult terrain and climate of the area have hindered development.

Ball clay. Ball clays are a very fine grained, sedimentary kaolinitic type of clay with unfired colours ranging from white to 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 clays. They are comprised principally of fine-particle kaolinite and quartz, with less alumina and more silica than kaolins. Ball clays are extremely refractory and are used as a plastic bond in various types of refractory products. 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 in other areas. Clay from the Willows area has been used for many years in the potteries at Medicine Hat and Vancouver; however, the lack of proper quality control, the distance from large markets and lack of reserves have been the principal disadvantages affecting the widespread use of this material. Some ball clays from the Flintoft area are being used for white-to-buff facing brick and for household pottery and crocks.

Fire clay. Fire clays contain high percentages of alumina or 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 the composition, physical characteristics, refractoriness, use, or association with other minerals. Descriptive terminology includes plastic fire clays, nonplastic fire clays, high-alumina fire clay, siliceous fire clay, flint clay, coal measure 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 1699° to 1724°C). Intermediate-duty refractories require raw materials having a PCE of about 29 (approximately 1659°C) or higher. Clays having a PCE of less than 29 but greater than 15 (approximately 1430°C) may be suitable for low-duty refractories or ladle brick as well as for other clay products. No known Canadian fire clays are sufficiently refractory for the manufacture of superduty refractories without the addition of some very refractory material such as alumina. However, in 1967 a sample from northern Ontario having a PCE of 33 was examined at the Mines Branch, Ottawa.

Various grades of good-quality fire clays 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, as previously stated, 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 fire clay. These provinces import most of their requirements from the United States.

Stoneware clay. Stoneware clays are similar to low-grade plastic fire 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 semirefractory 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 of southern Saskatchewan and southeastern Alberta. The Eastend, Saskatchewan area 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

One hundred and sixty-five companies operated 188 plants classified within the ceramics industry in

Table 1. Canada, production of clay and clay products from domestic sources, 1970-71

	1970	1971p
	($)	($)
Production, shipments from domestic sources, by provinces		
Newfoundland	37,304	–
Nova Scotia	1,588,576	1,765,000
New Brunswick	510,303	660,000
Quebec	6,417,611	6,890,000
Ontario	25,197,229	28,775,000
Manitoba	378,408	345,000
Saskatchewan	1,252,967	990,000
Alberta	3,235,348	3,350,000
British Columbia	4,043,324	4,050,000
Total, Canada	42,661,070	46,825,000
Production* (shipments) clay and clay products from domestic sources		
Building brick	28,017,784	32,581,000
Structural tile	830,180	672,000
Drain tile	5,301,744	4,083,000
Sewer pipe and flue linings	3,384,845	3,891,000
Pottery (stoneware, artware, flower pots, etc.)	1,989,740	1,889,000
Other clay products (fireclay, china clay, other clay, firebrick)	3,137,407	3,709,000
Total	42,661,700	46,825,000

Source: Statistics Canada. Breakdown of totals by Statistics Section, Mineral Resources Branch.
pPreliminary. – Nil.

Table 2. Canada, imports and exports of clay, clay products and refractories

	1970		1971p	
	(st)	($)	(st)	($)
Imports				
Clays				
Bentonite	344,153	3,276,000	346,800	3,295,000
Drilling mud	6,196	889,000	4,542	1,500,000
China clay, ground or unground	237,608	5,598,000	202,440	5,718,000
Fire clay, ground or unground	68,008	884,000	67,706	1,093,000
Clays, ground or unground	60,445	658,000	61,883	654,000
Clays and earth, activated	31,397r	1,999,000	12,699	1,757,000
Subtotal, clays	747,807	13,304,000	696,020	14,017,000
Clay products				
Brick-building	(M)		(M)	
glazed	1,746	135,000	1,361	115,000
NES	19,634	1,309,000	16,995	1,233,000
Building blocks	..	303,000	..	210,000
Clay bricks, blocks and tile, nes	..	167,000	..	102,000
Earthenware tile	(ft^2)		(ft^2)	
under 2½ X 2½"	13,291,106	2,913,000	12,631,192	2,606,000
over 2½ X 2½"	16,903,547	3,320,000	18,103,836	3,704,000
Subtotal, brick, blocks, tile	..	8,147,000	..	7,970,000
Tableware, ceramic	..	24,446,000	..	27,577,000
Porcelain insulating fitting	..	5,053,000	..	5,275,000
Pottery settings and firing supplies	..	244,000	..	188,000
Subtotal, porcelain, pottery	..	29,743,000	..	33,040,000
Refractories				
Fire brick	(M)		(M)	
Alumina	4,102	4,806,000	25,964	4,553,000
Chrome	386	548,000	6,911	1,009,000
Magnesite	670	2,367,000	5,964	1,844,000
Silica	2,020	1,862,000	18,007	3,351,000
nes	39,071	14,502,000	174,556	13,090,000
Refractory cements and mortars	..	2,169,000	..	2,612,000
Acid-proof brick	..	280,000	..	307,000
	(st)		(st)	
Crude refractory materials	5,511	462,000	8,287	688,000
Grog (refractory scrap)	15,873	652,000	17,919	594,000
Refractories, nes	..	2,316,000	..	1,437,000
Subtotal, refractories	..	29,964,000	..	29,485,000
Total clays, clay products and refractories	..	81,158,000	..	84,512,000
By main countries				
United States		44,951,000		42,764,000
Britain		19,965,000		21,191,000
Japan		8,605,000		10,318,000
West Germany		1,762,000		4,539,000
Italy		640,000		1,072,000
Ireland		495,000		825,000
France		803,000		650,000
Greece		839,000		606,000
Austria		523,000		310,000
Belgium and Luxembourg		204,000		283,000
Other countries		2,371,000		1,954,000
Total		81,158,000		84,512,000

Table 2 (Cont'd)

	1970		1971p	
	(st)	($)	(st)	($)
Exports				
Clays, ground and unground	1,863	52,000	4,386	103,000
Clay products	(M)		(M)	
Building brick, clay	10,193	1,375,000	9,511	995,000
Clay bricks, block, tiles, nes	..	324,000	..	611,000
Subtotal, brick, blocks, tiles	..	1,699,000	..	1,606,000
High-tension insulators and fittings	..	757,000	..	1,031,000
Tableware	..	3,178,000	..	3,259,000
Subtotal, porcelain, tableware	..	3,935,000	..	4,290,000
Refractories				
Fire brick and similar shapes	..	8,074,000	..	7,938,000
	(st)		(st)	
Crude refractory materials	838,849	815,000	765,102	760,000
Refractories nes	..	1,053,000	..	843,000
Subtotal, refractories	..	9,942,000	..	9,541,000
Total, clays, clay products and refractories	..	15,628,000	..	15,540,000
By main countries				
United States		9,926,000		9,603,000
Britain		720,000		787,000
French Oceania		35,000		748,000
South Africa		286,000		412,000
Dominican Republic		371,000		318,000
Puerto Rico		323,000		255,000
France		208,000		253,000
Ireland		70,000		230,000
Greece		280,000		219,000
Chile		217,000		188,000
Other countries		3,192,000		2,527,000
Total		15,628,000		15,540,000

Source: Statistics Canada.
pPreliminary; .. Not available; nes Not elsewhere specified; M = 1,000; – Nil; rRevised.

Canada in 1971, based on data available to the Mineral Resources Branch.

A group of one hundred and thirty-seven plants (72 per cent) within the industry manufactured clay products. The plants in this group were classified as brick and tile plants, clay sewer pipe plants, porcelain and pottery plants and refractory plants. A second group of plants manufactured products classified as abrasives, glass or porcelain enamels. The list of the active companies together with accompanying detailed information, is included in Operators List 6, "Ceramic Plants in Canada", published by the Mineral Resources Branch.

The Atlantic provinces. Four brick and tile manufacturing plants are operated in the Atlantic provinces, of which the L. E. Shaw Limited plant at Lantz, Nova Scotia has the largest capacity: 1,700,000 pieces per month from four kilns. This company will modernize its plant within the next year effecting a 15 to 20 per cent increase in production capacity. Local raw materials include shale, stoneware clays, red clay and fire clay. Sewer pipe and flue lining are manufactured at the Shaw plant at Lantz and also by Standard Clay Products, Limited in New Glasgow, Nova Scotia.

A porcelain and pottery plant operated by E and A Lorenzen at Lantz, Nova Scotia produced art pottery and stoneware, utilizing local sources of red and buff clay. Ahlstrom Canada Limited of Moncton, New Brunswick manufactured glass containers from imported silica sand and nepheline syenite. Two porcelain enamel plants in New Brunswick, each with

Table 3. Canada, shipments of clay products produced from imported clay[1] 1968-70

	1968		1969		1970p	
	(ft²)	($)	(ft²)	($)	(ft²)	($)
Glazed floor and wall tile	11,878,031	5,154,000	13,271,356	5,506,000	11,228,107	4,722,000
Electrical porcelains	..	12,310,000	..	9,245,000	..	12,590,000
Pottery, art and decorative ware	..	2,304,000	..	2,133,000	..	1,643,000
Pottery, other	..	1,555,000	..	1,767,000	..	308,000
Sanitary ware	..	2	..	2	..	9,174,000
All other products	..	18,607,000	..	16,167,000r		5,211,000
Total		39,930,000		34,818,000		33,648,000

Source: Statistics Canada.
[1]Does not include refractories. [2]Included under "all other products".
pPreliminary; rRevised; . . Not available; – Nil.

a total capacity of over one hundred thousand square feet per month, utilized local sources of commercial frit for the spray and dip processes on cast iron and sheet steel.

Quebec. Eight major brick and tile plants operated in Quebec producing brick products from local shale and clay. Drain tile was produced, also from the above raw materials; no production of sewer pipe was reported in 1971. Twelve porcelain and pottery plants, including five which manufactured art pottery, were operated. Chinaware, electrical porcelain, wall and floor tiles and vitreous sanitary ware were also produced. The principal consumers of ceramic-grade china clay and ball clays imported their entire requirements from the United States or England. Refractory products were produced by five plants which manufactured products such as bricks, mortars or ramming mixes. Most raw materials, including ball clay, fire clay and flint clay, were imported. Two abrasive plants manufactured crude silicon carbide and one manufactured resin bond sanding disks. Domestic raw materials included silica sand, fused alumina and resins. Petroleum coke was imported. Four glass plants were operated using mainly domestic raw materials. Five porcelain enamel plants situated in Montreal used domestic commercial frit primarily in spray and dip processes on cast iron and sheet steel.

Ontario. Thirty-nine major brick and tile plants operated in Ontario in 1971. Most of these are situated in the Toronto-Hamilton area and in the extreme southwestern part of the province. Local resources of common clay or shale were utilized, primarily in the stiff-mud process for the manufacture of brick and tile products. Two companies manufactured sewer pipe and flue lining by the stiff-mud process from imported fire clay and local raw materials. Porcelain and pottery were manufactured by twenty-three plants, nine of which make art pottery. The remainder produced mainly sanitary ware products, electrical porcelain, wall and floor tile and dinnerware products. Nepheline syenite, common clay and feldspar were acquired locally. Ball clay, china clay, talc and flint were imported. Refractory products were manufactured by thirteen plants from imported ball clay, fire clay, refractory grogs and flint clays. Bonded abrasives were manufactured at six

Table 4. Canada, shipments of refractories, 1968-70

	1968		1969		1970p	
	(st)	($)	(st)	($)	(st)	($)
Fire clay blocks and shapes[1]	126,449	17,708,000	126,841	17,624,000	125,071	21,489,000
Cements, mortars, castables	72,020	10,853,000	83,578	12,731,000	66,089	8,886,000

Source: Statistics Canada.
[1]Includes fire clay blocks and shapes, fire brick, etc., made from domestic clays, and rigid fire brick, 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, 1962-71

	Production					
	Domestic clays[1]	Imported[2] Clays	Total	Refractory[3] Shipments	Imports[4]	Exports[4]
			(millions of dollars)			
1962	37.8	22.5	60.3	20.0	48.3	5.4
1963	38.2	25.2	63.4	21.0	43.9	7.6
1964	40.8	30.2	71.0	25.3	54.7	8.9
1965	42.8	31.4	74.2	27.1	59.4	10.3
1966	43.0	36.1	79.1	29.3	71.7	12.6
1967	44.3	35.7	80.0	30.8	70.7	13.7
1968	48.7	39.9	88.6	33.0	65.4	11.8
1969	51.2	34.8ʳ	86.0ʳ	35.2	76.3	14.0
1970	42.7	33.6	76.3	42.0	81.2	15.6
1971ᵖ	46.8	..	..	..	84.5	15.5

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 fire brick and similar shapes, all types, refractory cements, mortars, castables, plastics, etc., plus all other products shipped. [4]Includes refractories.
ᵖPreliminary; .. Not available; ʳRevised.

plants using about 50 per cent domestic raw materials. All silicon carbide utilized was obtained in Canada. The principal product of the seven glass plants operating in Ontario, in 1971, was glass containers. One plant produced glass fibre insulating products from imported silica sand and domestic nepheline syenite, limestone, soda ash and dolomite. Porcelain enamel was produced by nineteen plants.

The Prairie Provinces. In Manitoba local stoneware clay was used to manufacture facing brick by the stiff-mud and dry-press processes using a single tunnel kiln. In Saskatchewan brick and sewer pipe were manufactured at one plant and common and face brick at another. The former plant, in Regina, and the latter, in Estevan, have reported capacities of 1500 thousand pieces per month. In Alberta, plants in Edmonton, Medicine Hat and Redcliff manufacture brick and tile. At the Medicine Hat plant sewer pipe was also produced. In southern Alberta six porcelain and pottery plants manufactured products including stoneware, sanitary ware, electrical porcelain and dinnerware. Local common clay and fire clay, local and imported ball clay and imported china clay were used. Only one refractory plant operated in the region in 1971, producing fire clay refractories, special shapes and face brick from local deposits of fire clay in the Whitemud formation. Four glass plants, all in Alberta, produced varied products including containers, glass wool, glass fibre mats, pipe covering and plastic pipe, primarily from domestic raw materials.

British Columbia. Brick and tile were manufactured at three plants and sewer pipe at one plant in B.C. These are situated in Vancouver, Haney and Kilgard. One plant, located in Coquitlam, manufactured vitreous sanitary ware and three plants, located in Haney, Sardis and Sasnichton, manufactured art pottery. Refractories were produced at three plants that are situated in Abbotsford, Surrey and Vancouver. Glass containers were manufactured by one company in Burnaby and one in Lavington.

Summary. Preliminary production and import figures for clay and clay products in 1971 are higher than the

Table 6. Canada, consumption (available data) of china clay by industries, 1969-70

	1969	1970
	(short tons)	
Ceramic products	13,840	12,050
Paint and varnish	3,141	2,811
Paper and paper products	142,975	141,288
Rubber and linoleum	8,829	8,354
Other products[1]	9,451	16,092
Total	178,236	180,595

Source: Statistics Canada. Component breakdown by Statistics Section, Mineral Resources Branch.
[1]Includes miscellaneous chemicals, cleansers, detergents, soaps, medicinals and pharmaceuticals, and other miscellaneous products.

Table 7. Ceramic plants in Canada, 1971[1]

Plants	Atlantic	Quebec	Ontario	Prairie Provinces	British Columbia	Total
Brick and tile	4	8	39	6	3	60
Clay sewer pipe	2	–	2	2	1	7
Porcelain and pottery	1	12	23	6	4	46
Refractories	–	5	13	1	3	22
Glass	1	4	7	4	2	18
Abrasives	–	3	6	–	–	9
Porcelain enamel	2	5	19	–	–	26

Note: Some plants produce more than one group of products.
[1] Based on data available to National Mineral Inventory, Mineral Resources Branch.

final figures for 1970. This suggests that, in general, producers operated at a higher percentage of capacity.

The brick and tile manufacturing industry accounts for approximately one third of the total number of 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. Seven plants manufacture sewer pipe, mainly from domestic common clay, shale or stoneware clay along with some imported shale and fire clay. Of the porcelain and pottery producers, six sanitary ware plants, eight electrical porcelain plants, five wall tile plants (including two that also make floor tile), four 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 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 22 plants that manufactured refractories utilized imported clay including ball clay, fire clay and kaolin, as the principal ingredients in many of their products. Only the British Columbia producers of refractories were able to operate with domestic raw materials by making use of the clay at Sumas Mountain. 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. The eighteen glass plants mainly utilized domestic sources of raw materials, except those in Quebec and Ontario, which accounted for most of the imported silica sand used. Porcelain enamel was produced by a total of 26 plants, which largely utilized domestic materials, commercial frit being the product of greatest importance.

Specifications and uses

The following specifications, published by the Canadian Standards Association, are applicable to the specified clay products manufactured in Canada:

- A 82.1 – 1965 Burned clay brick
- A 82.2 – 1967 Methods of sampling and testing brick
- A 82.3 – 1954 Sand-lime building brick
- A 60.1 – 1969 Vitrified clay pipe
- A 60.2 – 1962 Methods of testing vitrified clay pipe
- A 60.3 – 1969 Vitrified clay pipe joints
- A 82.5 – 1954 Structural clay non-load bearing tile (reaffirmed 1967)
- A 82.6 – 1954 Standard methods for sampling and testing structural clay – tile (reaffirmed 1954 and 1967)

Appropriate specifications of the American Society for Testing and Materials (ASTM) generally meet the requirements of other processes used and products manufactured in Canada. Some are as follows:

- C 71 – 68 Standard definitions of terms relating to refractories
- C 24 – 56 Standard method of test for pyrometric cone equivalent (PCE) of refractory materials
- C 27 – 70 Standard classification of fire clay and high-alumina refractory brick
- C 242 – 60 Terms relating to ceramic whitewares and related products (reapproved 1970)

Expanded common clays or shales are utilized as thermally expanded lightweight aggregates and are reviewed separately in "Lightweight Aggregates".*

*See No. 1 in this series of mineral preprints.

World review

United States. Total mine production of clays was an estimated 54,800,000 short tons in 1971 which was essentially the same production as that in 1970. United States imports of clays were estimated to be 85,000 tons in 1971, a nearly fixed requirement. The major uses for clays, other than those used in the heavy clay products industry, were as follows: refractories, paper manufacture, iron ore pelletizing, absorbent and filtering uses, and pottery and stoneware.

The United States export market for quality kaolin has generally increased in recent years, primarily from the fast rate of industrial growth in several European countries. The primary reason for the upward trend was the world shortage of coating grades of kaolin for paper manufacture; however, the 1971 market was depressed by the general recession that affected all major western economies. United States producers are taking a much greater interest in developments in the European industry, possibly with the aim of offsetting the effects of Britain's entry into the European Economic Community. The forecast domestic demand for clays in the United States to the year 2000 calls for an average annual growth of 2.8 to 4.5 per cent. It is expected that average prices for most clays will rise slowly, reflecting higher quality requirements for the specialty clays and increasing costs associated with land acquisition, land rehabilitation and environmental factors. Also, greater recovery of byproducts and coproducts is expected to occur as processing technology improves and as problems of solid waste disposal become increasingly acute.

Britain. Britain is the world's leading producer of kaolin and ball clay for export. Approximately 20 per cent of total clay production is exported, according to sources available to the United States Bureau of Mines. Major growth areas for British exports have been Europe, United States and Japan. In western Europe the major users were West Germany, France and the Netherlands, which reflects their high per capita rate of paper consumption.

Europe and Japan. The kaolin operations in continental Europe and Japan are reported to be mainly small-scale, using limited processing equipment and producing products of lower grade because of the lack of high-grade kaolin deposits. The industry in these countries is fragmented except in Bavaria (West Germany), Brittany (France) and Czechoslovakia, where significant advances are being made. Present kaolin consumption in Europe and Japan is largely in paper manufacture; however, local producers have so far had only limited success in that market because quality is inadequate. West Germany, with a production of nearly 500,000 long tons, is the second largest producer of kaolin in Europe. Most of the kaolin is used in the ceramic and other industries to which it is best suited. West Germany imports nearly 600,000 tons of kaolin annually, mainly for paper manufacture. The bulk of this requirement is supplied by Britain, followed by the United States. Exports of kaolin from West Germany are usually in the refined form and total about 90,000 tons a year.

Czechoslovakia is the largest producer of kaolin in eastern Europe. Output is reported to be approximately 340,000 tons a year. The high quality of the kaolin is indicated by the fact that 179,000 tons is consumed in paper manufacture. There are indications that Czechoslovakia is increasing its share of the European market. In France many companies produce kaolin, although operations are generally small, fairly widely dispersed and relatively distant from major markets. On the other hand, the industry in Brittany, which accounts for about 80 per cent of France's output, is expected to expand its production substantially in coming years through more integrated support by a central body in Paris. Also, a major American producer has acquired an interest in an operation in Brittany, which will bring new capital to the region along with additional technical and marketing expertise.

Spain has the fourth largest production of kaolin in western Europe. In 1970 the estimated total was 285,000 tons. Output was reported to have expanded over two and a half times since 1960 and, according to the National Mining Plan, which envisages a complete modernization of many of the operations, output will double again by 1976.

Greece produces approximately 60,000 tons of kaolin annually, almost all for domestic consumption.

Denmark produces between 30,000 and 35,000 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 produces no kaolin but acts as a very important distribution point for American and British clay entering Europe.

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 per year. Total kaolin output is approximately 190,000 tons per year, most of which is low-grade material. Most of the production goes into the manufacture of refractories, for which it is well suited. However, relatively large tonnages are also used in filler applications, such as in rubber. The United States is the principal source of imports, supplying about 100,000 long tons annually. Lesser amounts of kaolin are imported from South Korea, Britain and the U.S.S.R.

Outlook

The broad aspects of the clay industry in Canada have not changed appreciably for many years. Common clays and shales that are suitable for brick and tile manufacture occur in most regions of Canada and are used extensively in the ceramic industry. On the other hand, deposits of the high-quality clays, including kaolins, fire clays and ball clays, are generally scarce and contain small tonnages. The few known deposits of fire clays and ball clays in the developed areas of Canada are already being utilized. Much work has been carried out on deposits containing kaolin but these have not been developed because of small size, high cost of beneficiation, or remoteness from transportation or industry. Ontario and Quebec are particularly deficient in developed deposits of refractory- or kaolin-type clays. Lower-quality deposits in the United States and Britain, the major export countries, will be utilized in the future, probably at increased cost and as a result of the development of improved beneficiation methods.

In recent years there has been a great increase in the number of ways that kaolin can be processed, both by chemical and mechanical means. This trend is continuing as producers endeavour to increase markets and to meet the tighter specifications of industries in which consumers are placing much more emphasis on brightness, colour and viscosity than formerly. In the United States continued demand for paper grades, particularly for coating, is assured, barring adequate substitutes. The rubber industry will continue to be a big consumer, but its steady intake in recent years suggests that it will not expand very rapidly in the future. The ceramics market apparently has some characteristics in common with the rubber market in that it is already large and not expanding at a fast rate. Paint and fibreglass applications are good potential growth areas, if the right grades are developed; newer uses, such as for catalysts in oil-refining, may prove to be growing markets. A recent increase of up to 25 per cent in the refractories market has been noted in Canada. Proportionally, there has been a decrease in the use of fireclay brick and an upswing in materials such as high alumina, alumina silicates, basic refractories and monolithics (a family of materials applied by means of casting, ramming, or gunning to form a virtually jointless furnace lining). The major emphasis in the production of refractory products will be to cope with the higher operating temperatures and greater throughputs required in industrial furnaces; the higher-grade, superduty refractories are apparently in heavy demand. 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 petrochemical industry, by increased demands for high-purity glass and by the need for more economical production of ceramics.

Population increases, together with general construction and industrial requirements, will continue to produce demands for products manufactured from common clay and shale. These raw materials, 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. Demands in industry have indicated that some end-use products such as brick and tile find competition from cement, glass, metals and plastic manufacturers. On the other hand, clays, being generally less expensive and very satisfactory for their intended uses, are generally 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 separately.*

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 Oil, Paint and Drug Reporter, December 27, 1971

Ball clay	
Domestic crushed, moisture-repellent, bulk, car lots, fob Tennessee	($ per ton) 8 – 11.25
Imported lump, bulk, fob Great Lakes ports	40.50
Imported, airfloated bags, car lots, Atlantic ports	70
China clay (kaolin)	
Water washed, fully calcined, bulk, car lots, fob Georgia	68
Partially calcined, same basis	59
Dry-ground, air floated soft, fob Georgia	14

*No. 6 in this series.

from Saskatchewan to the United States but the quantity continued to decline in 1971. In total approximately 40 per cent of Canadian production was exported in 1971 and this proportion is expected to increase in the near future once the mines with long-term export contracts reach full production capacity.

Imports. Canada imported 17.7 million tons of bituminous coal and 400,000 tons of anthracite coal, all from the United States in 1971. Imports were down slightly in 1971 due to decrease in demand for coking coal by the steel industry in Canada and also as a result of the six-week bituminous coal miners' strike in the United States. Bituminous coal used for thermal power generation accounted for slightly over 50 per cent of total imports. Over 90 per cent of the imported coal entered Ontario with the remainder going primarily to Quebec and Nova Scotia. The coal is purchased largely under long-term contracts and in the case of steel companies, often from captive mines. Spot shipments from individual United States coal companies located in the Appalachian region of the eastern United States are used to fill out requirements to meet demand.

Thermal power industry

Coal used for thermal electric power generation totalled 17.3 million tons in 1971 up from the 15.2 million tons of coal consumed by this industry in 1970. At the end of 1971, existing coal-fired electric power plants had a combined total capacity of 8,870 megawatts (MW). In addition, plans have been announced by utility companies in several provinces which will result in the construction of thermal plants totalling about 6,000 MW of capacity which is to be completed within six years. This expansion is expected to occur principally in Ontario and to a lesser extent in Alberta and Saskatchewan. Of the 17.3 million tons of coal used for power generation in 1971 it is estimated that 8 million tons was domestic coal and the remainder was imported from coal mines in northwest Virginia and Pennsylvania for power generation in Ontario.

The Hydro-Electric Power Commission of Ontario (Ontario Hydro) which is the largest consumer of coal for electricity generation in Canada purchases most of its coal by long-term contracts with United States coal companies. Extra demand is met by spot purchase. In 1971, Ontario Hydro had less difficulty obtaining all its coal requirements than in 1970 and as a result lowered its purchases of Saskatchewan lignitic coal. By the end of 1971, Ontario Hydro had nearly completed construction of the first of eight 500-megawatt units at its Nanticoke Generating Station at Port Dover on Lake Erie. When all eight units are in operation this will be the largest coal-fired generating station in Canada.

Table 7. Canada, supply and demand of coal, 1960 and 1970

	1960	1970
	short tons	
Supply		
Production	10,776,333	16,604,164
Landed imports	12,290,054	19,353,343
Total inventory change	−267,102	+1,808,653
Total supply	23,333,489	34,148,854
Demand		
Exports	852,921	4,391,575
Domestic Sales		
Electric utilities	1,846,149	15,199,471
Mining and manufacturing	8,263,796	3,709,026
Coke making	5,288,217	8,092,379
Subtotal	15,398,162	27,000,876
Retail sales	4,615,323	641,562
Railways	655,418	138,016
Ship's bunker	306,494	251,034
Government and institutional	307,000	159,000
Subtotal	5,884,235	1,189,612
Coal mine and local use	860,189	430,141
Unaccounted for	337,982	1,136,650
Total domestic demand	22,480,568	29,757,279
Total demand	23,333,489	34,148,854

Source: Statistics Canada.

Table 8. Contractual amounts of bituminous coal for export to Japan

	1972	1973	1974	1975
	(millions of short tons)			
British Columbia				
Kaiser Resources Ltd.	4.9	4.9	4.9	4.9
Fording Coal Limited	2.1	3.4	3.4	3.4
Total, British Columbia	7.0	8.3	8.3	8.3
Alberta				
Cardinal River Coals Ltd.	1.1	1.1	1.1	1.1
Coleman Collieries Limited	1.7	1.7	1.7	1.7
McIntyre Porcupine Mines Limited	2.2	2.2	2.2	2.2
The Canmore Mines, Limited	0.4	0.4	0.4	0.4
Total, Alberta	5.4	5.4	5.4	5.4
Total	12.4	13.7	13.7	13.7

During the year, six of the eight units at Ontario Hydro's Richard L. Hearn Generating Station in Toronto were modified to burn natural gas. Conversion of the other two units is under way. When the conversion is completed, four 100-MW units will use only gas and four 200-MW units will burn either coal or gas or a combination of both. Conversion of the station from coal to natural gas was undertaken to reduce air pollution.

Further expansion planned by Ontario Hydro includes a 300-MW addition at its Thunder Bay plant near Fort William. During 1971 investigations were renewed to study the possibility of using the lignitic coal situated at Onakawana in northeastern Ontario as a fuel for thermal power generation. Burning tests were conducted at Thunder Bay which indicated the lignite could be used as a fuel for power plant. Currently, investigations are proceeding on the economic feasibility of such a plant at Onakawana.

A total of 2.8 million tons of lignite was used for power generation in both Saskatchewan and Manitoba in 1971. Lignite consumption in Saskatchewan levelled off in 1971 after a 10-year period of substantial growth in which lignite used for power generation increased from 770,000 tons to over 2 million tons. In Saskatchewan's Esteven area, work was started on the third 150-MW unit with completion scheduled for 1973. Upon completion, this station will be one of the largest lignite-fired power plants in North America.

Commissioning of a 100-MW extension to the lignite-fired Queen Elizabeth Power Station at Saskatoon was delayed for one year due to damage of the generator. A new mining operation in the Estevan area will be established to supply approximately half of the future coal requirements of the Boundary Dam Generating Station at Estevan over the next 15 years. The agreement was signed with Manitoba and Saskatchewan Coal Company (Limited). The existing agreement with Utility Coals Ltd. also covering approximately half of the Boundary Dam coal requirements was extended to 1978.

To determine the location and extent of lignite resources as a first step in assessing the feasibility of developing further thermal power generation in the province an extensive federal and provincial government sponsored survey of lignite reserves in southern Saskatchewan was begun in 1971.

In Manitoba, at Brandon and Selkirk two lignite-fired generating stations having a combined capacity of 392 MW consumed approximately 575,000 tons of lignite.

In Alberta, Calgary Power Ltd. now operates two large power plants on Lake Wabamun, 40 miles west of Edmonton. These plants used subbituminous coal from mines adjacent to the plants. Calgary Power's newest generating station, the Sundance, operated its first full year in 1971 and used approximately a million tons of coal. At this plant a second 286-MW

Table 9. Canada, coal used by thermal electric generating stations by provinces, 1956-1971
(thousands of short tons)

	Nova Scotia	New Brunswick	Ontario	Manitoba	Saskat-chewan	Alberta	Total Canada
1956	399	291	469	1	225	1	1,386
1957	459	213	724	1	303	–	1,700
1958	431	144	317	98	375	–	1,365
1959	426	141	196	34	435	187	1,419
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[p]	760	300	9,435	575	2,200	4,025	17,295

Source: Statistics Canada.
[p]Preliminary; –Nil.

unit is under construction and will be completed in early 1974. Approximately 1.4 million tons of subbituminous coal a year are required for each unit. With an ultimate capacity of about 1,300 MW from 4 units tentatively planned for the Sundance station, the adjacent mine will need a production capacity of 5 to 6 million tons of coal a year.

At the mine site of McIntyre coal mine near Grande Cache, Canadian Utilities, Limited is building a $34 million thermal power plant designed to use oxidized and middling coal. The first unit of this plant will have a 150-MW capacity and initial steaming is planned for June 1972. Canadian Utilities also plans to install and put into service by 1975, another 150,000-MW unit at the Battle River Station at Forestburg.

Coke industry

In 1971, approximately 7.3 million tons of coking coal were carbonized to produce 5.1 million tons of coke. Coke production was down about 10 per cent from the 5.7 million tons produced in 1970. The decline in coke output is partially attributable to a slight reduction in pig iron production which decreased from 9.1 million tons in 1970 to 8.7 million tons in 1971.

About 90 per cent of the coking coal used to make coke in Canada was imported from the United States. The three major steel companies that operate coke oven plants in Hamilton and Sault Ste. Marie have captive coal mines in the United States. Of the 6.7 million tons of coking coal imported from the United States in 1971, it is estimated that 3.8 million tons or 57 per cent came from captive mines.

Approximately 4.1 million tons, or 80 per cent of the coke produced in Canada is charged to blast furnaces for pig iron production. The remainder of the coke is consumed by foundries, chemical plants and nonferrous smelters. Coke trade has been small as illustrated by the 317,765 tons of coke valued at $6.6 million that were exported in 1971 to seven countries of which the United States was the largest purchaser. Production of coking coal byproducts such as coke oven gas, ammonia, tar and light oils is a small industry in Canada because they are readily available as petroleum-based products.

In 1971 an average of 1.4 tons of coking coal was required for each ton of coke produced in Canada. The coke rate, the amount of coke consumed per ton of pig iron produced, was 1,080 pounds in 1971, unchanged from the rate in 1970. Based on the coking rate and the amount of coal required for each ton of coke, it is estimated that in 1971 about 1,560 pounds (0.78 tons) of coking coal were required per ton of 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 coke oven plants 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 Algoma Steel Corporation, Limited (Algoma) has one of the largest coke-making plants in Canada, located at Sault Ste. Marie, Ontario. In 1971 the coke oven plant capacity was reduced by approximately 600,000 tons of coal as the result of the temporary shutdown of an old coke oven battery for major repairs. Repair of the old battery will extend its useful life to 1977 in order to defer the large expenditure which will be required to replace the battery. Algoma had lower coke production in 1971 which reflects the shutdown of No. 5 blast furnace for about 11 weeks for relining. In 1971 Algoma started work on the development of a new low volatile metallurgical coal mine near Beckley, West Virginia. All the coking coal used in the company's coke oven plant comes from subsidiary mining firms in West Virginia.

The Steel Company of Canada, Limited (Stelco), as in the previous two years, had difficulty in 1971 in obtaining adequate supplies of satisfactory coking coals. Stelco imports the bulk of its coking coal from subsidiary mines in the United States for its coke oven plant in Hamilton, Ontario. The six-week United States coal miners' strike which began on October 1 curtailed operations and reduced output at the Chisholm, Olga and Mathies mines, owned by Stelco.

In 1971 Stelco continued construction of a new battery of 83 coke ovens scheduled for completion in 1972. These ovens will bring the total number of Stelco's ovens to 347. Coke oven capacity will increase by 25 per cent by this addition to approximately 2.6 million tons of coke annually requiring about 3.6 million tons of coking coal.

In 1971 Stelco began construction of a new mine in West Virginia which will have an annual production capacity of 700,000 tons of high volatile bituminous coking coal. Stelco also acquired a $12\frac{1}{2}$ per cent interest in a company which is developing a low volatile bituminous coal property in West Virginia. Production is scheduled to begin in 1973 and Stelco's share will amount to 187,000 tons annually.

Dominion Foundries and Steel, Limited (Dofasco), also located in the Hamilton area, has a coke oven plant with an annual capacity of 1,312,500 tons of coke. In 1971 Dofasco completed a fifth battery of coke ovens, including facilities for the collection and treatment of waste gases created in the coking process. The new ovens represent a 34 per cent increase in coke-making capacity. Dofasco's annual coking coal requirements are approximately 1.8 million net tons. About 70 per cent of these requirements is provided either from long-term contracts or from a property in which Dofasco has an ownership interest. A 20-year agreement was recently negotiated with Eastern Associated Coal Corp. to supply the company with 500,000 tons of coal annually. This is in addition to a current long-term contract with this company which provides Dofasco with approximately 550,000 tons of

Table 10. Coke oven and other carbonization plants in Canada

Coke Plant	Battery and No. of Ovens	Oven Type	Year Built	Plant Capacity, Coal	1971 Coke Production	Byproducts
				(thousands of tpy)	(thousands of tpy)	
The Algoma Steel Corporation, Limited, Sault Ste. Marie, Ontario	No. 5 - 86	Koppers-Becker Underjet	1943	2,100	1,481	Naphthalene, light oil, gas, tar
	No. 6 - 57	Koppers-Becker Underjet	1953			
	No. 7 - 57	Wilputt Underjet	1958			
	No. 8 - 60	Wilputt Underjet	1967			
The Steel Company of Canada, Limited, Hamilton, Ontario	No. 3 - 61	Wilputt Underjet	1947	2,670	1,824	Tar, sulphate of ammonia, sodium phenolate, gas, light oil
	No. 4 - 83	Wilputt Underjet	1952			
	No. 5 - 47	Wilputt Underjet	1953			
	No. 6 - 73	Otto Underjet	1967			
Dominion Foundries and Steel, Limited, Hamilton, Ontario	No. 1 - 25	Koppers-Becker Gun Type Comb	1956	1,800	1,013	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			
Cape Breton Development Corporation, Sydney, Nova Scotia	No. 5 - 53	Koppers-Becker Underjet	1949	900	385	Tar, crude oil, gas
	No. 6 - 61	Koppers-Becker Underjet	1953			
Gaz Metropolitain, inc., Ville La Salle, Quebec	No. 1 - 59	Koppers-Becker	1928	626	264	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	40	Creosote, lignite, tar, lignite pitch
Kaiser Resources Ltd., Natal, British Columbia	10 units	Curran-Knowles	1939	245	162	Crude tar, gas
	10 units	Curran-Knowles	1943			
	16 units	Curran-Knowles	1949			
	16 units	Curran-Knowles	1952			
	3 units	Mitchell	1963			

Table 11. Canada, coal coke production and trade

	1970		1971^p	
	(short tons)	($)	(short tons)	($)
Production				
Ontario	4,590,000	*	4,288,288	*
Other provinces	1,078,219	*	817,504	*
Total	5,668,219	*	5,105,792	*
Imports				
United States	331,984	10,666,000	459,171	14,928,000
West Germany	62,969	2,462,000	187,257	7,219,000
Total	394,953	13,128,000	646,428	22,147,000
Exports				
United States	129,077	2,562,000	184,125	4,862,000
Netherlands	–	–	79,285	981,000
West Germany	36,420	393,000	23,410	224,000
Belgium-Luxembourg	3,315	188,000	13,955	113,000
Norway	–	–	8,978	136,000
Spain	18,105	242,000	7,783	340,000
Dominican Republic	–	–	229	8,000
Romania	48,968	1,447,000	–	–
Italy	24,091	233,000	–	–
Venezuela	13,914	149,000	–	–
Total	273,890	5,214,000	317,765	6,664,000

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 12. Canada, coke production and trade, 1961-1971

	Production		Imports		Exports	
	Coal Coke	Petroleum Coke	Coal Coke	Petroleum Coke	Coal Coke	Petroleum Coke
	(st)	(st)	(st)	(st)	(st)	(st)
1961	3,899,545	964,494	288,815	365,744	174,295	52,408
1962	4,021,774	201,985	247,304	338,068	126,024	31,858
1963	4,280,797	199,636	234,610	369,037	136,316	18,016
1964	4,342,982	206,815	315,763	440,607	85,969	21,225
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	8,436
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^p	5,105,792	200,143	646,428	733,958	317,765	12,314

Source: Statistics Canada.
^{p}Preliminary.

coal annually. Another principal source is through the company's ownership interest in the Itmann Coal Company of West Virginia where purchases from this mine normally total in excess of 250,000 tons annually. Dofasco recently negotiated an option with Imperial Metals and Power Ltd. to examine and develop if it proves feasible, certain coal properties in British Columbia.

Cape Breton Development Corporation (DEVCO) at Sydney, Nova Scotia produced 385,000 tons of coke from 546,000 tons of coking coal. In 1971 about 75 per cent of the coal that went into coke production was Nova Scotia coal from Devco's mines and the remainder was imported from the United States. In 1971 Devco implemented a program to repair its old coke ovens so that production can be stabilized at 600,000 tons annually by 1973.

Table 13. World coal production

Continent	1966	1967	1968	1969	1970[p]
	(thousands of short tons)				
North America	560,567	578,944	570,615	584,376	619,929
South America	7,542	8,274	8,395	9,039	9,150
Europe	1,870,657	1,841,241	1,856,496	1,873,376	1,891,895
Africa	58,124	59,154	62,236	63,493	64,154
Asia	552,915	441,024	529,005	560,635	598,224
Oceania	64,640	67,721	73,325	81,020	86,200
World					
Lignite (estimate)	808,386	792,304	811,071	846,023	868,180
Bituminous and anthracite (by subtraction)	2,306,059	2,204,054	2,289,001	2,325,916	2,401,372
Total, all type	3,114,445	2,996,358	3,100,072	3,171,939	3,269,552

Source: U.S. Bureau of Mines, *International Coal Trade.*
[p]Preliminary.

Cobalt

D. D. BROWN

Production (shipments) of cobalt in Canada in 1971 was 4,992,000 pounds valued at $10.9 million compared with 4,561,213 pounds valued at $10.2 million in 1970. Canada is one of the major cobalt-producing countries recovering nearly 90 per cent of its cobalt as a byproduct of nickel-copper ores and the balance, also a byproduct, from silver-cobalt ores.

Approximately half of the world's current annual supply of some 22,000 tons of cobalt metal is produced as a byproduct of copper recovery in the Zaire Republic (Congo). The other principal cobalt-producing countries are Canada, Zambia, Finland and the U.S.S.R.

The United States General Services Administration sold 892,483 pounds of cobalt metal granules from stockpile surplus in 1971. The total sales value was $1,914,235, an average of nearly $2.15 a pound of contained cobalt. Total sales from United States cobalt stockpile in 1970 were 2.5 million pounds; sales in 1969 and 1968 were 8.9 and 5.5 million pounds. The sale of 40.2 million pounds excess cobalt in stockpile was authorized in July 1970.

Published prices for cobalt had remained unchanged until late in December 1971 since November 1969 when the producer's price of cobalt metal shot, 99 per cent Co, in 250 kilogram drums, was increased to $2.20 a pound at New York and Chicago. On December 27, 1971, African Metals Corporation, the importer of Congolese (Republic of Zaire) cobalt refined in Belgium, raised its New York price of cobalt shot to $2.45 a pound. Effective December 29, 1971, Sherritt Gordon Mines, Limited raised the price of its high-purity powder 20 cents to $2.55 a pound of cobalt in 10-ton lots; Sherritt briquettes were raised 20 cents to $2.58 a pound. Finnish cobalt producers and French refiners of Moroccan cobalt concentrates also raised their prices by similar amounts. Falconbridge raised the price of its electrolytic cobalt to U.S. $2.45 a pound on February 3, 1972.

Outlook

Cobalt has been in abundant supply with demand reduced in Europe and the United States during the latter half of 1970 through 1971. New and increased supply from Zaire, Canada, Zambia, Finland and other sources will be available to meet all normal demands. Sales from the United States General Services Administration stockpile will extend over several years and they, coupled with increasing production, will assure reasonably stable prices and adequate supply. Byproduct production of cobalt from new nickel mines will provide additional supplies over the longer term.

Canadian production

Canada's production of 4.99 million pounds of cobalt in 1971 compared with 4.56 million pounds in 1970 reflects a continued growth in 1971 despite domestic nickel production cutbacks effected during the second half of 1971.

The International Nickel Company of Canada, Limited (Inco) delivered 1.98 million pounds of cobalt in both 1971 and 1970.

Table 1. Canada, cobalt production, trade and consumption, 1970-71

	1970		1971p	
	(pounds)	($)	(pounds)	($)
Production[1] (all forms)				
Ontario	3,692,529	8,211,391	4,235,000	9,262,000
Manitoba	817,718	1,885,888	700,000	1,551,000
Quebec	50,966	110,087	57,000	123,000
Total	4,561,213	10,207,366	4,992,000	10,936,000
Exports				
Cobalt metal				
United States	699,798	1,701,000	632,518	1,693,000
South Africa	47,631	342,000	30,020	176,000
France	26,738	69,000	27,219	67,000
Japan	49,859	80,000	7,711	44,000
Belgium & Luxembourg	–	–	31,466	33,000
West Germany	298	2,000	13,200	32,000
Other countries	15,525	54,000	6,368	21,000
Total	839,849	2,248,000	748,502	2,066,000
Cobalt oxides and salts[2]				
Britain	1,642,700	2,396,000	2,466,500	3,351,000
Belgium & Luxembourg	202,300	394,000	–	–
Total	1,845,000	2,790,000	2,466,500	3,351,000
Consumption[3]				
Cobalt contained in				
Cobalt metal	246,463	..	126,976	..
Cobalt oxide	23,894	..	37,011	..
Cobalt salts	56,673	..	57,007	..
Total	327,030	..	220,994	..

Source: Statistics Canada.
[1] Production (cobalt content) from domestic ores. [2] Gross weight.
[3] Available data reported by consumers.
p Preliminary; – Nil; . . Not available.

Table 2. Canada, cobalt production, trade and consumption, 1962-71
(pounds)

		Exports		Imports		
	Production[1]	Cobalt Metal	Cobalt Oxides and Salts[2]	Cobalt Ores[2]	Cobalt Oxides[2]	Consumption[3]
1962	3,481,922	542,565	1,629,900	–	40,936	383,442
1963	3,024,965	739,229	1,098,300	2,500	28,291	364,594
1964	3,184,983	593,607	1,654,900	..	..	365,851
1965	3,648,332	292,191	1,414,200	..	..	366,036
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
1971p	4,992,000	748,502	2,466,500	..	..	220,994

Source: Statistics Canada.
[1] Production from domestic ores, cobalt content. From 1967, production includes cobalt content of Inco and of Falconbridge shipments to overseas refineries, but prior years exclude Inco shipments to Britain.
[2] Gross weight. [3] Consumption of cobalt in metal, oxides and salts.
p Preliminary; – Nil; . . Not available.

Table 3. World production of cobalt

	1969	1970p	1971e
	(short tons of contained cobalt)		
Republic of Zaire[1]	11,000	15,386	12,500
Finland	1,800	..	1,222
Morocco	1,700	666	550
Cuba	1,700	..	..
U.S.S.R.	1,650	..	..
Zambia	1,650	2,400	1,750
Canada	1,628	2,280	2,496
West Germany	864	..	..
Australia	330	260	275
Total	22,322	25,692*	22,321*

Sources: U.S. Bureau of Mines, *Minerals Yearbook for 1969;* for 1970 and 1971 U.S. Commodity Data Summaries, January 1972. For Canada, Statistics Canada.
*Totals include estimates for unavailable figures, 1970 = 4,700; 1971 = 3,528.
[1] Changed from Democratic Republic of the Congo (Kinshasa) on October 27, 1971.
p Preliminary; .. Not available; e Estimated.

Cobalt deliveries of Falconbridge Nickel Mines Limited were lower in 1971 than in 1970. The company produces cobalt at its refinery in Kristiansand, Norway, from nickel-copper matte shipped from Canada. Falconbridge is planning the construction of a new nickel refinery at Becancoeur, Quebec, that will produce cobalt salts as a byproduct; completion of this plant is expected in 1975.

Sherritt Gordon Mines, Limited produced 561,000 pounds of cobalt compared with 803,000 pounds in 1970. Cobalt is recovered as a byproduct of Sherritt's nickel-refining operations at Fort Saskatchewan, Alberta. The refinery treats nickel-copper concentrates from the company's Lynn Lake mine in Manitoba and from nickel- and cobalt-bearing materials received on a toll basis.

Cobalt is recovered as a byproduct of the smelting and refining of silver-cobalt concentrates from the mines of the Cobalt and Gowganda areas of Ontario.

World production

World production of cobalt in 1971 was estimated at 22,321 tons (cobalt content) compared with 25,692 tons in 1970. The decline was due to a reduction of cobalt output from Republic of Zaire, Zambia and Morocco. Sales from United States stockpile surplus were only 446 tons (cobalt content) compared with 1,200 tons in 1970.

Consumption and uses

Consumption of cobalt in Canada in 1971 was 220,994 pounds, 57 per cent as cobalt metal, 26 per cent as cobalt salts and 17 per cent as cobalt oxide.

Table 4. United States, consumption of cobalt by uses, 1969-70

	1969	1970
	(thousands of pounds cobalt content)	
Steel (ingots and castings)		
High-speed and tool	575	534
Stainless steel	73	114
Alloy (excluding stainless and tool)	282	136
Cutting and wear-resistant materials		
Cemented or sintered carbides	1,747	1,395
Other materials	39	981
Welding and hardfacing rods, materials	302	181
Magnetic alloys	2,560	2,379
Nonferrous alloys	4,334	2,871
Electrical materials	1,108	..
Chemical and ceramic uses		
Catalysts	286	402
Ground coat frit	133	129
Glass decolorizer	74	69
Pigments	191	155
Other	5	7
Miscellaneous and unspecified	1,104	1,403
Salts and driers		
Lacquers, varnishes, paints, inks, pigments, enamels, feeds, electroplating (estimate)	2,577	2,616
Total	15,390	13,367

Source: U.S. Bureau of Mines, *Minerals Yearbook, 1969,* and preprint from the U.S. Bureau of Mines, *Minerals Yearbook, 1970.*
.. Not available; – Nil.

The United States is the largest consumer of cobalt but produces only minor amounts as a byproduct of iron ore that contains some cobalt-bearing pyrite. Domestic refiners and processors produce a range of cobalt products from duty-free imported ores, concentrates and unwrought cobalt metal.

Consumption of cobalt in the United States in 1971 was 5,309 tons compared with 5,985 tons in 1970*. Cobalt was supplied to users and processors in the form of metal (75 per cent), salts and driers (19 per cent), oxide (5 per cent) and other unspecified forms including scrap (1 per cent).

The more important uses of cobalt are in high-temperature, high-strength alloys, magnet alloys, high speed and tool steel, hard-facing rod, cemented carbides and other ferrous and nonferrous alloys. The series of cobalt-chromium hardfacing alloys called

*U.S. Bureau of Mines, Mineral Industry Surveys, February 22, 1972.

"stellite" were forerunners of the high-temperature alloys used near their melting temperatures which are designated "superalloys". The cobalt-base superalloys contain 50 per cent or more cobalt with chromium, nickel, tungsten and molybdenum, and many of the nickel-base and iron-base superalloys contain 10 to 20 per cent cobalt.

Cobalt is used in a wide variety of magnetic materials in electrical and electronic applications. The principal types of cobalt-containing magnetic materials are the magnet steels for permanent and soft magnets (easily magnetized) containing cobalt in amounts varying from a fraction of one per cent up to 50 per cent. The Alnico alloys which contain aluminum, nickel and cobalt include the important permanent magnet alloy Alnico 5, containing 8 per cent aluminum, 14 per cent nickel, 24 per cent cobalt, 51 per cent iron and 3 per cent copper. The magnetic iron oxides called "ferrites" such as $CoFe_2O_4$, and various soft magnet materials, contain up to 50 per cent cobalt with iron, chromium, nickel, tungsten, vanadium, titanium, or aluminum.

Metallic uses account for about 75 per cent of cobalt consumption. Nonmetallic uses include organic and inorganic cobalt salts used as driers, in paints, varnishes and enamels, ground-coat frit, and in pigments, dyes, catalysts and in animal feeds. The radioactive isotope cobalt 60, is used for therapeutic purposes and in the examination of metal castings and forgings for flaws.

Minerals and occurrences

Cobalt is widely dispersed in the rocks of the earth's crust, constituting about 0.0023 per cent, compared with 0.0080 per cent for nickel, and ranks thirty-fourth in order of relative abundance. The amount of cobalt estimated to be in the earth's crust is more than that of lead (.0016 per cent) and about one third that of copper (.0070 per cent). World production is about 24,000 tons a year while annual production of lead is approximately 3.8 million tons and of copper 6.9 million tons. Unlike lead, it seldom occurs in concentrations and is usually recovered as a minor byproduct associated with the ores of copper, nickel, iron, silver, manganese, lead and zinc.

The important types of cobalt minerals are sulphides, arsenides, and oxides. The principal sulphide minerals are linnolite (Co_3S_4) and carrollite (Co_2CuS_4). The principal arsenides are smaltite ($CoNiAs_2$), cobaltite (CoAsS), safflorite ($CoFeAs_2$), and skutterudite ($CoNiAs_3$). The principal oxide minerals are erythrite, or cobalt bloom ($3CoOAs_2O_8H_2O$), heterogenite($CoO_2CO_2O_36H_2O$), and asbolite ($CoO_2MnO_24H_2O$). The cobalt minerals are seldom found in sufficient quantity to be mined for cobalt alone.

Prices

Prices of cobalt in U.S. currency

	Dates of Price Changes	
	Nov. 17, 1969	Dec. 27, 1971
	(U.S. $)	(U.S. $)
Cobalt metal per lb fob New York, Chicago		
Shot 99% +		
less than 50 kg	2.30	2.55
50-kg drums	2.25	2.50
250-kg	2.20	2.45
Powder, 99% +, 300 mesh		
50-kg drums	2.91	. .
extra fine, 125-kg drums	3.49	. .
Fines, 95-96%, per lb contained Co		
regular, 500 lb	2.76	. .
300-mesh	2.78	. .
Briquettes, 10-ton lots, per lb, contained	2.38	. .
Cobalt oxide, per lb, 250 lb		
Ceramic, delivered, 5¢ more west of Mississippi		
70-71%	2.20	. .
72½-73½%	2.26	. .
Metallurgical, fob N.Y., 75-76% (per lb contained)	2.85	. .

. . Not available.

Tariffs

Canada

Item No.		British Preferential	Most Favoured Nation	General
		(%)	(%)	(%)
33200-1	Cobalt ore	free	free	free
35103-1	Cobalt metal, excluding alloys, in lumps, powders, ingots or blocks	free	free	25
35110-1	Cobalt metal, in bars	free	10	25
92824-2	Cobalt oxides	free	10	20
92824-1	Cobalt hydroxides	10	15	25
	(From July 15, 1971 to January 31, 1973)	free	15	25

United States

Item No.		
601.18	Cobalt ore	free
632.20	Cobalt metal, unwrought, waste and scrap	free

		On and After Jan. 1, 1971	On and After Jan. 1, 1972
		(%)	(%)
632.84	Cobalt metal alloys, unwrought	10.5	9
633.00	Cobalt metal, wrought	10.5	9
418.68	Cobalt compounds other than cobalt oxide and cobalt sulphate	7	6
426.24, 426.26	Cobalt salts	7	6
418.60, 418.62	Cobalt oxide and Cobalt sulphate	0.9¢ per lb	0.7¢ per lb

Sources: Canada – The Customs Tariff and Amendments, Department of National Revenue Customs and Excise Division, Ottawa. United States – Tariff Schedules of the United States Annotated (1971) TC Publication 344.

Columbium (Niobium), Tantalum and Cesium

G.P. WIGLE and M. GAUVIN

St. Lawrence Columbium and Metals Corporation, near Oka, Quebec, is Canada's only producer of columbium and has one of only two mines in the world that produce columbium in pyrochlore concentrates as a principal primary product; the other, larger operation, is near Araxá, Brazil. Canada produced 2,597,667 pounds of columbium pentoxide (Cb_2O_5) in its fiscal year ended September 30, 1971, compared with 4,886,957 pounds in the 12 months of the prior fiscal year.

St. Lawrence Columbium reduced production early in 1971 because of customers' accumulated stocks of columbium concentrates and ferrocolumbium. Production was suspended on June 24 and resumed at less than capacity on August 9. The company began production of columbium-bearing pyrochlore concentrates in October 1961 at a milling rate of 500 tons a day, which was increased to 1,300 tons a day by 1969 and the present capacity of 2,000 tons a day in 1970.

Three countries accounted for 89 per cent of United States imports of 3 million pounds (gross weight) of columbium concentrates in 1971 – Brazil, 61 per cent; Canada, 12 per cent; and Nigeria, 16 per cent. United States imports of tantalum concentrate were about 1.2 million pounds (gross weight). The principal suppliers were: Canada, 46 per cent; the Republic of Zaire, 16 per cent; and Brazil, 15 per cent.*

The demand for columbium and tantalum declined in the latter part of 1970 and during 1971. Major suppliers reduced production. Columbite ore, cif U.S. ports, at the beginning of the year was $1.00-1.05 a pound of contained pentoxides for material having a Cb_2O_5 to Ta_2O_5 ratio of 10 to 1; year-end prices were $0.75-0.85 a pound. Contract rates for Canadian pyrochlore, fob the mine site, were $1.15-1.20 a pound of Cb_2O_5 throughout the year. Brazilian pyrochlore for contract sales, fob shipping point, remained at $1.15 a pound of Cb_2O_5. Tantalite ore at the beginning of the year was $6.75-7.50 a pound of Ta_2O_5, 60 per cent basis, cif U.S. ports, and at year-end was $6.25-6.75 a pound of Ta_2O_5.

*U.S. Bureau of Mines, Mineral Industry Surveys, December 27, 1971.

There were no sales of columbium or tantalum from United States stockpiles in 1971. The stockpiles at December 31, 1971 contained approximately 9.2 million pounds of columbium with 5.9 million pounds authorized for sale. Tantalum materials in stockpiles contained 4.1 million pounds of tantalum, roughly 808,000 pounds in excess of specified objectives.

Canada's commercial production of tantalum began in 1969 at the Bernic Lake, Manitoba mine of Tantalum Mining Corporation of Canada Limited.* Concentrates were first shipped in the second half of 1969. The company supplied about 46 per cent of the United States imports of tantalum in 1970 and 1971 and became the principal U.S. source of tantalum supply, followed by the Congo and Brazil.

Developments

Copperfields Mining Corporation Limited and Quebec Mining Exploration Company (SOQUEM) continued development of the St-Honoré columbium pyrochlore deposit some 7 miles north of Chicoutimi, Quebec. Ore reserves within the block drilled to a depth of 850 feet are calculated to be 40 million tons grading 0.76 per cent Cb_2O_5. A declined adit was driven 2,700 feet, including 1,900 feet in the ore zone, to provide a production entry and bulk sampling for metallurgical test work.

*Wholly owned subsidiary of Chemalloy Minerals Limited.

Table 1. Canada, columbium (niobium) and tantalum production, trade and consumption, 1970-71

	1970		1971^p	
	(pounds)	($)	(pounds)	($)
Production				
Columbium (Cb_2O_5 content of shipments)	4,694,239	4,819,951	2,176,000	2,199,000
Tantalum (Ta_2O_5 content of shipments)	317,024	2,251,182	450,000	3,150,000
Imports[1] from United States				
Columbium and columbium alloys wrought	–	–	5,061	246,560
Tantalum and tantalum alloys wrought, nes	854	54,408	1,487	91,192
Tantalum and tantalum alloys, unwrought waste and scrap	1,870	15,988	14,237	32,296
Tantalum and tantalum alloy powder	2,480	77,274	3,100	97,220
Exports[2] to United States				
Columbium ore and concentrates	1,270,362	668,983	301,217[3]	249,104[3]
Consumption by the steel industry				
Ferrocolumbium and ferrotantalum-columbium (Cb and Ta-Cb content)	292,000	..	..	..

Source: Statistics Canada, except 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 FT135. Values in U.S. currency. [3]1st eleven months.
^{p}Preliminary; – Nil; .. Not available.

Table 2. Canada, columbium (niobium) and tantalum production, trade and consumption, 1961-71

	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, Ferrocol. and ferrotantalum-columbium Cb and Ta-Cb Content
	(lb)	(lb)	(lb)	(lb)	(lb)	(lb)	(lb)	(lb)
1961	62,229	–	–	–	–	–	35,575	22,000
1962	1,016,514	–	–	–	–	–	1,509,928	26,000
1963	1,393,444	–	–	–	–	–	823,202	34,000
1964	2,163,359	–	–	–	–	–	1,940,133	74,000
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
1971^p	2,176,000	450,000	5,061	1,487	14,237	3,100	301,217[4]	..

Source: Statistics Canada, unless otherwise notea.
[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 FT410. Quantities in gross weight of material. [3]From U.S. Department of Commerce, Imports of Merchandise for Consumption, Report FT135. Quantities in gross weight. [4]1st 11 months.
^{p}Preliminary; .. Not available; – Nil.

St. Lawrence Columbium and Metals Corporation reduced production early in 1971 because of customers' accumulated stocks of columbium concentrates and ferrocolumbium. Production was suspended for six weeks beginning on June 24 and was resumed at less than capacity on August 9. This company began its original production of columbium-bearing pyrochlore concentrates in October 1961 at a milling rate of 500 tons a day which was increased to 1,300 tons a day by 1969 and 2,000 tons a day in 1970. St. Lawrence Columbium is Canada's only producer of columbium.

Columbium Mining Products Ltd., controlled by Coulee Lead and Zinc Mines Limited, has a columbium property in the Oka, Quebec, area with drill-indicated reserves estimated at 38.2 million tons grading 0.40 per cent Cb_2O_5.

Imperial Oil Enterprises Ltd., Consolidated Morrison Explorations Limited, and associated companies have a large columbium-pyrochlore property in the James Bay Lowlands area about 31 miles south of Moosonee, Ontario. It was reported that drilling indicated about 80,000 tons per vertical foot averaging 0.52 per cent columbium pentoxide (Cb_2O_5).

Outlook

Columbium was in reduced demand in 1971, in common with other refractory and reactive ferroalloy metals. Demand improved in the latter part of the year and production, which had been reduced, was again increased to somewhat higher rates. The principal producers, Brazil and Canada, have ample reserve capacity to meet growing demand in the 1970's. There are potential new producers in both countries that can be brought to production in two years or less and new production was expected from the Republic of Zaire. The columbium market should be adequately supplied for upwards of five years.

The demand for tantalum was also reduced in 1971 with the temporary recession in the electronics industry. Canada's only tantalum producer Tantalum Mining Corporation of Canada Limited maintained its position as the world's leading producer of tantalum raw materials.

World production

Noncommunist world production of columbium and tantalum mineral concentrates in 1971 was an estimated 24,000 tons consisting of concentrates of

Table 3. Production of columbium (Cb) and tantalum (Ta) concentrates, 1969-71[1,2]

	1969			1970p			1971		
	Cb	Ta	Cb-Ta	Cb	Ta	Cb-Ta	Cb	Ta	Cb-Ta
	(thousands of pounds, gross weight)								
Brazil									
Pyrocholore	19,099	–	–	29,288	–	–	32,000	450	–
Columbite-tantalite	152	448	–	..	..		..	..	..
Canada									
Pyrochlore	6,829	–	–	9,838	–	–	10,000		
Tantalite	–	246	–	–	594	–		650	–
Nigeria	3,340	13	–	3,564	10	–	3,800	15	..
Republic of Zaire	–	–	184	–	–	323	170	170	..
Mozambique									
Columbite-tantalite	–	–	141	–	–	77	40	40	..
Microlite	–	182	–	–	65	–	..	..	..
Malaysia	–	–	132	–	–	..	62	60	..
Australia	–	–	95				..	..	..
Thailand	–	–	57			126	..	..	..
Ruanda	–	–	49				..	..	..
Portugal	–	–	21	–	–	7	..	..	..
Rep. of South Africa	–	–	9	–	7	–	..	..	..
Argentina	–	–	3,560	–	–	..	..	..	..
Other countries[3]	–	–	58				105	115	..
Totals	29,420	889	4,306	42,690	676	533	46,177	1,500	..

Source: U.S. Bureau of Mines *Minerals Yearbook 1970* 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, French Guiana, Ivory Coast, Spain, Uganda, U.S.S.R.
pPreliminary; – Nil; .. Not available.

columbite, tantalite and columbium-bearing pyrochlore. Production in 1970 was 22,000 tons.

The largest producer of columbium since 1966 is the Companhia Brasileira de Metalurgia e Mineração (CBMM) at its columbium-pyrochlore mine near Araxá, Brazil. The company's production of columbium pentoxide increased from 1.4 million pounds of contained pentoxide in 1965 to 17 million pounds of contained Cb_2O_5 in pyrochlore concentrates in 1970. A small facility was constructed for the production of high-purity concentrates.

The Zairian Government and Belgian interests were jointly preparing a columbium-pyrochlore mine for production at Bingo in Kivu Province. The deposit was reported to have proven ore reserves of 2.3 million tons containing 3.6 per cent columbium pentoxide to depths of 25 metres.

Nigeria had been the perennial leader until 1965 in the production of columbium since recovery began there about 1933. Columbium continued to be recovered almost exclusively as a coproduct of tin mining. Nigerian columbite accounted for about 12 per cent of the world's columbite production in 1970.

Consumption and use

Canada's consumption of columbium and tantalum in the form of ferroalloys was 292,000 pounds in 1970 compared with 244,000 pounds in 1969 and 288,000 pounds in 1968. The market for ferrocolumbium is growing in the iron and steel industry for such applications as the manufacture of oil and gas transmission pipe and in a range of steel alloys.

Table 4. Consumption of ferrocolumbium, ferrotantalum-columbium and other columbium and tantalum materials in the United States by end use, 1970

End use	Contained Columbium plus Tantalum
	(lb)
Steel	
Carbon	705,621
Stainless and heat-resisting	522,007
Alloy (excludes stainless and heat-resisting)	829,416
Superalloys	472,321
Alloys (excludes alloy steels and superalloys)	36,370
Miscellaneous and unspecified[1]	24,793
Total	2,590,528

Source: U.S. Bureau of Mines, Preprint from *Minerals Yearbook, 1970,* Columbium and Tantalum.
[1] Includes tool steel.

The United States is the largest consumer of columbium and tantalum. Its imports of columbium concentrates were 5.7 million pounds in 1970 and 4.2 million pounds in 1969. Imports of tantalum mineral concentrates were about 1 million pounds.

Most of the United States wholly imported supply of columbium and tantalum is used to make ferrocolumbium and ferrotantalum-columbium. The steel industry uses these ferroalloys in alloy and stainless steels, high-temperature alloys, nickel-base alloys and in some carbon steels. A primary reason for the addition of columbium to steel is to control and refine grain size. The improved strength-to-weight ratio, due to columbium in steel, gives weight savings in the making of oil and gas transmission piping. Both columbium and tantalum are finding increasing use through nuclear research and in high-temperature alloys for jet engines, turbines and rocket-engine parts. Tantalum is used in high-performance capacitors, electronics, chemical equipment, alloys and carbides.

The principal Canadian suppliers of ferrocolumbium are Union Carbide Canada Limited; Metallurg (Canada) Ltd.; Masterloy Products Limited; and St. Lawrence Columbium and Metals Corporation.

Among the Canadian users of columbium and tantalum are Atlas Steels Division of Rio Algom Mines Limited; The Algoma Steel Corporation, Limited; Black Clawson-Kennedy Ltd.; Dominion Foundries and Steel, Limited; The Steel Company of Canada, Limited; and Colt Industries (Canada) Ltd.

Minerals and ore occurrences

The principal commercial minerals of columbium and tantalum have been columbite and tantalite from pegmatites and from residual and placer deposits. Both minerals are coproducts of tin from alluvial deposits, notably in Nigeria, where concentrates containing 65 per cent or more of the combined oxides of columbium and tantalum are recovered. Major sources of columbium are now the columbium-bearing pyrochlore from carbonatite rock complexes in Canada and Brazil.

Canadian occurrences of columbium minerals in the complexes of carbonate-rich rocks, called carbonatites, include the columbium-pyrochlore producing mine of St. Lawrence Columbium and Metals Corporation near Oka, Quebec and, in Ontario, the James Bay property of Consolidated Morrison Explorations Limited, the Manitou Islands deposits of Nova Beaucage Mines Limited near North Bay, and the Lackner Lake property of Multi-Minerals Limited. There are 30 or more known carbonatite occurrences in Ontario, several in Quebec and Labrador and possibly four in British Columbia.

Columbite and tantalite have the theoretical compositions $(FeMn)OCb_2O_5$ and $(FeMn)OTa_2O_5$. They are closely related minerals and are frequently associated in ore occurrences. The two minerals vary in composition from the nearly pure columbite

($FeOCb_2O_5$), containing 82.7 per cent Cb_2O_5, to nearly pure tantalite ($FeOTa_2O_5$), containing 86.1 per cent Ta_2O_5. The iron and manganese contents vary widely; tin or tungsten may be present.

Pyrochlore is the columbium-rich member of the pyrochlore-microlite series of minerals which also contain small amounts of the oxides of other elements including the rare earths (e.g., cerium) and radioactive elements (e.g., uranium, thorium). Microlite is the tantalum-rich member of the mineral series.

The Bernic Lake, Manitoba ore deposit of Tantalum Mining Corporation of Canada Limited is a complex zoned pegmatite containing a variety of minerals. Most of the tantalum in this deposit occurs as stanniferous tantalite in small disseminated reddish brown to black grains varying in size from pinpoint to axe-shaped crystals one-eighth inch long. The chemical composition of the tantalite shows that it contains 70 per cent Ta_2O_5, 1.3 per cent Cb_2O_5 and an unusually high amount (13.2 per cent) of tin oxide (SnO_2).

Prices

United States prices quoted in Metals Week of December 20, 1971.

(1970 year-end prices are shown in brackets when differing)

	($)
Columbium ore	
Columbite, per lb pentoxide, nominal spot cif U.S. ports	
8-1 ratio	1.00
10-1 ratio	.75-.80 (1.00-1.05)
Pyrochlore, per lb Cb_2O_5	
Canadian fob mine or mill, contract only	1.15-1.20
Brazilian, fob shipping point, contract only	1.15
Ferrocolumbium per lb Cb, ton lots, fob shipping point	
Low-alloy, standard grades	2.45-2.65 (2.85-4.12)
High-purity grades (incl. Ni)	4.12-6.81 (4.79-6.76)
Columbium metal, per lb 99.5-99.8% free alongside, U.S. shipping port	

	Powder, roundel ($)	Ingot ($)
Reactor	12-23	17.50-28
Metallurgical	11-22	16-27

	($)
Tantalum ore, about 60% combined columbium and tantalum pentoxide, per lb Ta_2O_5, cif U.S. ports, spot	6.25-6.75 (6.75-7.50)
Tantalum metal, per lb	
Powder, fob shipping point, depending on size of lot	28.50-38.50
Sheet and rod, depending on grade	36-60

Tariffs

Canada

Item No.		British Preferential	Most Favoured Nation (%)	General (%)
32900-1	Columbium and tantalum ores and concentrates	free	free	free
35120-1	Columbium (niobium) and tantalum metal and alloys in powder, pellets, scrap, ingots, sheets, plates, bars, rods, tubing or wire for use in Canadian manufacture (expires 31 Oct. 1971)	free	free	25
37506-1	Ferrocolumbium, ferrotantalum, ferro-tantalum-columbium	free	5	5

United States Item No.		Effective on and after Jan. 1 1971	1972
		(%)	(%)
601.21	Columbium ores and concentrates	free	free
601.42	Tantalum ores and concentrates	free	free
628.15	Columbium metal, unwrought, waste and scrap (duty on waste and scrap suspended to June 3, 1973)	6	5
628.17	Columbium, unwrought alloys	9	7.5
628.20	Columbium metal, wrought	10.5	9
629.05	Tantalum metal, unwrought, waste and scraps (duty on waste and scrap suspended to June 3, 1973)	6	5
629.07	Tantalum, unwrought alloys	9	7.5
629.10	Tantalum metal, wrought	10.5	9

Sources: Canada – The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa. United States – Tariff Schedules of the United States Annotated (1971), TC Publication 344.

CESIUM

Pure cesium is a silvery white, soft, ductile metal with a melting point of 28.8°C, a boiling point of 708°C and a density of 1.87 gm/cm^3 at 20°C. Of the five naturally occurring alkali metals cesium has the highest vapour pressure, highest density, lowest boiling point, highest reactivity and lowest ionization potential. It is used in preference to other alkali metals when these properties are required particularly in such space age applications as space propulsion and energy conversion.

It emits electrons when exposed to visible light, ultraviolet light and infrared light. The metal is extremely active chemically, reacting violently with air and water. It is an efficient scavenger for traces of oxygen in highly evacuated containers.

Occurrences and recovery

Cesium is widely distributed but higher concentrations in the form of the rare mineral pollucite are normally found in complex, well-zoned pegmatite dykes that are rich in lithium minerals, notably lepidolite.

Pollucite, a cesium aluminum silicate, has a theoretical content of 45% Cs_2O but natural pollucite usually contains from 6-32% Cs_2O. Pollucite is similar in lustre and transparency to quartz. Its hardness is 6.5 and specific gravity 2.90. It is colourless to white, greyish or pinkish white.

Only three large deposits are known: 50,000 tons at Karabib in Southwest Africa, 100,000 tons at Bikita in Rhodesia, and 350,000 tons at the mine of Chemalloy Minerals Limited at Bernic Lake in Manitoba, Canada. A second Canadian occurrence is at the Valor property in Lacorne Township, northwestern Quebec, formerly owned by Massval Mines Limited.

At the Chemalloy property, Bernic Lake, pollucite occurs in the tantalum-bearing pegmatite as a lenticular mass or unit nearly 500 feet long and up to 60 feet in maximum thickness, a large part of which is nearly pure pollucite. The pollucite unit is gently dipping and, in general, concordant with the attitude of the pegmatite in which it occurs.

At the Valor property in Quebec, masses of pollucite up to 5 feet in maximum exposed dimensions are scattered through part of the lenticular core zone of a complex zoned dyke.

Thermochemical and hydrometallurgical methods are used for the production of cesium salts from pollucite. Cesium metals can be produced by the direct reduction of the pollucite ore under vacuum or by the thermochemical reduction of its salts under vacuum. Demand for cesium and its compounds has been so small that production of them can be considered to be on a laboratory scale.

Uses

Cesium is used in photoelectric cells, vapour rectifiers, spectrophotometers, photo multiplier tubes, time and frequency standards, biological research, medicine, scintillators, magnetometers and ion propulsion engines. The main consumption has been in the research and development of thermionic power conversion units and magnetohydrodynamic electrical power generators (MHD), both of which make use of its low ionization potential.

In thermionic converters the heat from nuclear reaction radiates to a surrounding metal 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 load.

In MHD plants, a fuel (coal, oil or gas) is burned. The hot gas is seeded with an easily ionized element such as cesium or potassium in the form of carbonates to increase its conductivity. The gas is accelerated through a chamber surrounded by a magnetic field producing electricity which is drawn off through electrodes placed in the channel. Major increases in efficiency and cheaper power with little or no pollution can be expected from MHD generators.

Consumption

Statistical data on the consumption and uses of cesium metal and compounds are not available, but what figures are available indicate that world consumption has probably been less than 10 tons a year. However, in the past two years Chemalloy Minerals Limited has shipped pollucite ore containing 250,000 pounds of Cs_2O to the U.S.S.R. to be used in the operation of three 7,500 kilowatt MHD pilot generators.

The Office of Coal Research in the U.S. Department of the Interior has negotiated a $2.4-million MHD development contract with AVCO Corporation, partly financed by private industry.

Prices

Raw pollucite ore is currently selling for about 75 cents a pound of contained Cs_2O. Cesium salts, which are now produced on a laboratory scale, sell for about $30 a pound.

Gibralter Mines Ltd. near McLeese Lake, B.C. Open pit mine in foreground, mill area in distance. (George Hunter photo.)

Copper

ROBERT J. SHANK

Production of recoverable copper from Canadian mines rose to a new record level of 714,507 tons in 1971, an increase of 41,790 tons from 1970. The value of this production declined, however, from $779,242,403 in 1970 to $754,517,000 in 1971 because of lower world prices for copper. Canada, with about 10 per cent of total world output, remained the fifth largest producer in the world after the United States, U.S.S.R., Chile and Zambia. Mine production is expected to grow strongly for the next two or three years and Canada could rise to third place in world production.

Output from the two domestic refineries fell by 16,670 tons in 1971 to 526,401 tons of refined metal. This amounted to 96 per cent of rated capacity as compared with the 99 per cent rate obtained in 1970. Smelter and refinery output is expected to rise sharply during the next few years as new capacity now being installed or planned comes on stream.

Producers' domestic shipments of refined copper in Canada fell again in 1971 to 221,053 tons from 237,838 tons in 1970. This reflects a continuing drop in foreign sales of fabricated and semifabricated copper and copper alloy products, perhaps partly because of the temporary imposition of a 10 per cent surcharge by the United States Government.

Internationally, copper continued in oversupply although the increase in stocks was marginal, being blunted by strikes in the United States that caused an estimated loss in output of some 250,000 tons of refined copper. Production problems in Chile and Zambia also kept output below expected levels.

World mine production of copper in 1971 at 7.0 million tons, was virtually unchanged from 1970 production. Significant declines were recorded in the United States, because of strikes, and Zambia and Peru, while increases occurred in Chile, Canada, U.S.S.R., and, in lesser amounts, in most other reporting countries.

World production of refined copper in 1971 dropped by about 4 per cent from 1970 to 8.0 million tons. This decline was mainly due to lower production in the United States and to a lesser extent in Zambia.

The consumption of refined copper at 7.9 million tons in 1971 was fractionally below 1970 with no one country showing a marked change. Business activity in North America, Europe and Japan remained sluggish and although copper stocks in London Metal Exchange warehouses rose to record levels, this was thought to reflect lower consumers' stocks.

The outlook for 1972 is one of hope tempered with pessimism; hope that there will be a strengthening in world business activity that will stimulate demand for copper, but pessimism that this will not occur quickly enough to prevent further increases in stocks. It appears most likely that 1972 will be a year of increasing mine production and improving, but uninspiring, consumption. On this basis, there should then be a buildup of stocks of concentrates and refined copper.

Table 1. Canada, copper production, trade and consumption 1970-71

	1970		1971p	
	(short tons)	($)	(short tons)	($)
Production[1]				
Ontario	295,093	340,839,782	303,631	320,634,000
Quebec	172,641	200,443,882	187,062	197,537,000
British Columbia	105,822	122,828,846	134,110	141,620,000
Manitoba	47,905	55,620,270	56,464	59,625,000
Newfoundland	15,193	17,639,532	12,875	13,596,000
New Brunswick	8,022	9,313,833	9,958	10,516,000
Saskatchewan	19,473	22,609,180	7,690	8,121,000
Yukon	7,880	9,148,995	2,550	2,693,000
Northwest Territories	661	766,578	150	158,000
Nova Scotia	27	31,505	17	17,000
Total	672,717	779,242,403	714,507	754,517,000
Refined	543,071		526,401	
Exports				
Copper in ores, concentrates and matte				
Japan	127,225	153,098,000	167,230	147,726,000
Norway	32,168	33,855,000	32,707	28,866,000
United States	7,868	7,238,000	8,339	6,337,000
Yugoslavia	–	–	4,775	2,865,000
Spain	4,294	4,089,000	2,443	2,421,000
Sweden	2,000	2,018,000	2,493	2,271,000
Other countries	5,564	6,271,000	6,871	5,512,000
Total	179,119	206,569,000	224,858	195,998,000
Copper in slag, skimmings and sludge				
United States	151	162,000	237	198,000
Britain	33	10,000	63	19,000
Sweden	38	6,000	–	–
Total	222	178,000	300	217,000
Copper scrap (gross weight)				
United States	4,093	4,615,000	7,355	6,964,000
West Germany	8,166	10,324,000	3,278	2,961,000
Spain	4,994	6,630,000	2,622	2,374,000
Belgium and Luxembourg	8,759	9,011,000	2,211	1,482,000
Japan	953	1,071,000	946	810,000
South Korea	87	111,000	751	664,000
Hungary	841	967,000	416	366,000
Britain	1,023	1,386,000	190	152,000
Other countries	2,491	2,926,000	459	322,000
Total	31,407	37,041,000	18,228	16,095,000
Brass and bronze scrap (gross weight)				
United States	2,196	1,621,000	9,101	6,124,000
Japan	4,074	3,487,000	2,878	2,040,000
West Germany	7,043	7,149,000	1,165	903,000
Italy	1,302	1,089,000	603	426,000
Belgium and Luxembourg	3,151	2,591,000	411	247,000
Britain	1,219	1,285,000	295	184,000
Other countries	1,212	1,135,000	452	272,000
Total	20,197	18,357,000	14,905	10,196,000

Table 1 (cont'd)

	1970		1971p	
	(short tons)	($)	(short tons)	($)
Copper alloy scrap, nes (gross weight)				
United States	31	30,000	191	130,000
Japan	152	124,000	100	98,000
Netherlands	16	22,000	12	17,000
Sweden	–	–	20	17,000
Other countries	482	429,000	112	37,000
Total	681	605,000	435	299,000
Copper refinery shapes				
United States	92,112	104,184,000	118,297	120,994,000
Britain	111,950	158,865,000	109,555	109,667,000
West Germany	39,077	54,131,000	33,702	33,548,000
France	16,251	22,013,000	12,317	12,573,000
Italy	4,297	5,582,000	8,631	8,596,000
Belgium and Luxembourg	6,798	8,406,000	7,588	7,680,000
Sweden	2,023	2,904,000	4,237	4,164,000
Portugal	2,909	4,178,000	3,859	3,897,000
Switzerland	2,332	3,154,000	3,748	3,630,000
Brazil	3,777	5,344,000	3,515	3,430,000
Other countries	10,877	16,269,000	6,914	6,846,000
Total	292,403	385,030,000	312,363	315,025,000
Copper bars, rods and shapes, nes				
Norway	3,260	4,730,000	3,595	3,668,000
Pakistan	2,026	3,144,000	2,949	3,070,000
United States	1,961	3,213,000	1,739	2,619,000
Switzerland	2,123	2,739,000	2,009	2,007,000
Denmark	2,680	3,785,000	1,619	1,704,000
Poland	55	77,000	1,432	1,525,000
Lebanon	–	–	1,129	1,173,000
Britain	1,745	2,237,000	855	903,000
Venezuela	363	508,000	795	880,000
Other countries	3,367	4,463,000	2,850	2,961,000
Total	17,580	24,896,000	18,972	20,510,000
Copper alloy wire and cable not insulated				
United States	294	585,000	105	199,000
Britain	27	57,000	9	15,000
Venezuela	1	2,000	2	14,000
Other countries	57	72,000	8	21,000
Total	379	716,000	124	249,000
Copper alloy fabricated materials nes				
Brazil	384	1,100,000	729	1,863,000
United States	543	1,128,000	587	868,000
Britain	2	9,000	66	105,000
Sweden	5	14,000	9	30,000
Other countries	58	143,000	76	101,000
Total	992	2,394,000	1,467	2,967,000

Table 1 (cont'd)

	1970		1971p	
	(short tons)	($)	(short tons)	($)
Copper plates, sheet,strip and flat products				
United States	6,859	10,923,000	7,009	10,172,000
Venezuela	308	514,000	256	392,000
Britain	334	553,000	66	101,000
New Zealand	36	64,000	57	82,000
Other countries	326	548,000	68	107,000
Total	7,863	12,602,000	7,456	10,854,000
Copper pipe and tubing				
United States	7,483	10,913,000	7,136	8,010,000
New Zealand	1,014	2,054,000	395	734,000
South Africa	232	404,000	464	695,000
Israel	1,009	1,595,000	442	567,000
Britain	917	1,631,000	335	466,000
Venezuela	94	185,000	157	267,000
Other countries	2,260	3,881,000	1,087	1,677,000
Total	13,009	20,663,000	10,016	12,416,000
Copper wire and cable (not insulated)				
United States	798	1,178,000	181	259,000
Jamaica	231	376,000	121	149,000
Iran	287	461,000	37	46,000
Panama	29	54,000	18	22,000
Bolivia	–	–	13	17,000
Other countries	1,298	1,908,000	96	137,000
Total	2,643	3,977,000	466	630,000
Copper alloy refinery, shapes, sections and flat products				
United States	9,449	13,517,000	11,392	13,802,000
Brazil	...	2,000	455	403,000
Venezuela	325	555,000	156	213,000
Japan	3,143	3,656,000	167	145,000
Peru	5	7,000	33	46,000
Britain	157	238,000	21	32,000
Other countries	1,355	1,666,000	57	68,000
Total	14,434	19,641,000	12,281	14,709,000
Copper alloy pipe and tubing				
United States	1,768	2,982,000	2,088	2,723,000
Israel	2	7,000	294	581,000
Japan	154	479,000	104	234,000
Puerto Rico	458	598,000	114	156,000
New Zealand	98	174,000	55	91,000
Britain	105	217,000	41	74,000
Other countries	102	214,000	133	250,000
Total	2,687	4,671,000	2,829	4,109,000
Wire and cable insulated[2]				
United States	26,913	54,784,000	8,635	18,090,000
India	132	105,000	3,295	5,754,000
Panama	579	786,000	633	921,000
Dominican Rep.	633	1,091,000	529	860,000
Turkey	1,735	1,229,000	831	747,000
Trinidad-Tobago	345	573,000	288	459,000
Chile	52	75,000	159	395,000

Tariffs
Canada

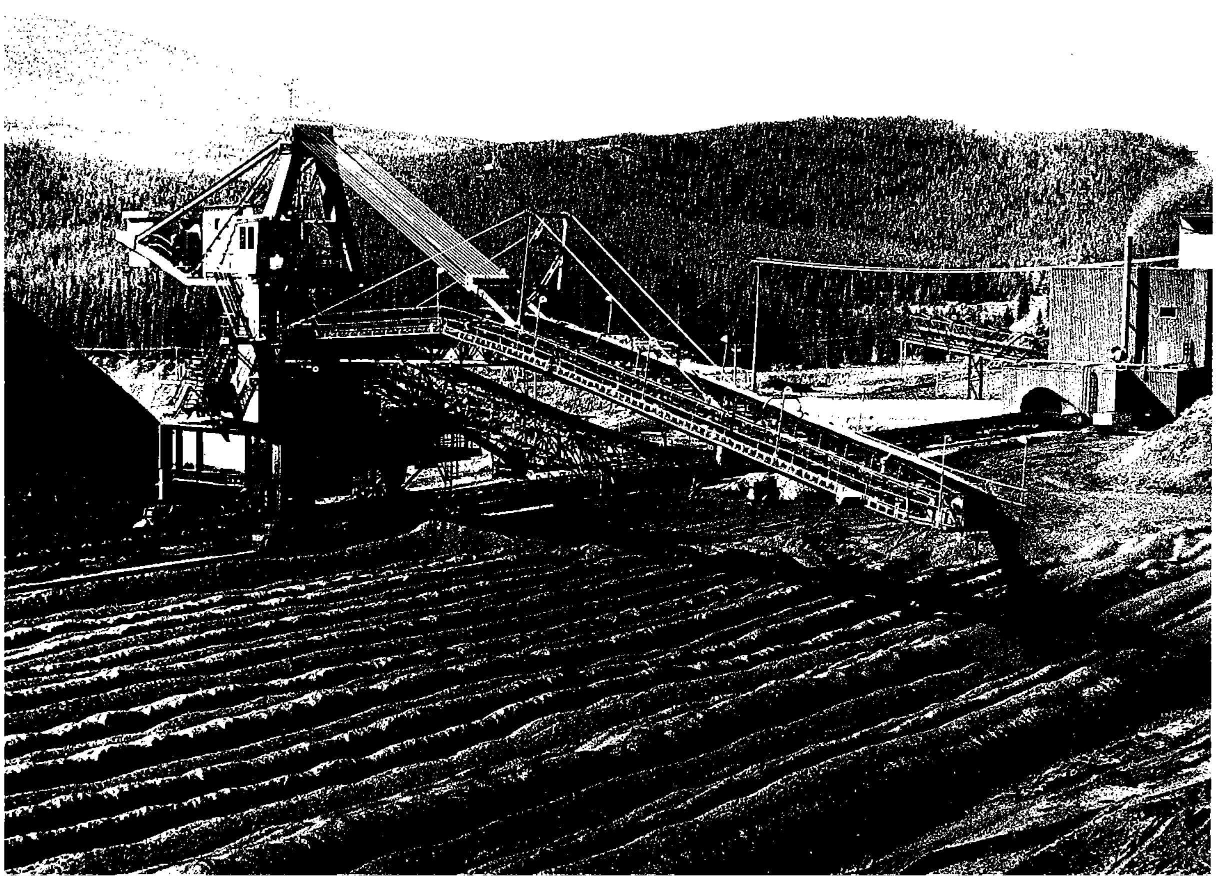
Item No.		British Preferential	Most Favoured Nation	General
		(%)	(%)	(%)
29500-1	Clays, including fire clay, and pipe clay not further manufactured than ground	free	free	free
29525-1	China clay	free	free	25
28100-1	Firebrick containing not less than 90 per cent silica; magnesite firebrick or chrome firebrick; other firebrick valued at not less than $100 per 1,000, rectangular shaped, not to exceed 100 × 25 in.^{3} for use in furnace and kiln repair or other equipment of a manufacturing establishment	free	free	free
28105-1	Firebrick, nop, of a class or kind not made in Canada, for use in construction or repair of a furnace, kiln, etc.	free	free	15
28110-1	Firebrick, nop	5	10	22½
28200-1	Building brick and paving brick	10	10	22½
28205-1	Manufactures of clay or cement, nop	12½	12½	22½
28210-1	Saggars, hillers, bats and plate setters, when used in the manufacture of ceramic products	free	free	free
28300-1	Drain tiles, not glazed	free	17½	20
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
28405-1	Earthenware tiles, for roofing purposes	free	17½	35
28415-1	Earthenware tiles, nop	12½	20	35
28500-1	Tiles or blocks of earthenware or of stone prepared for mosaic flooring	15	20	30
28600-1	Earthenware and stoneware, viz., demijohns, churns and crocks, nop	20	20	35
28700-1	All tableware of china, porcelain, semiporcelain or white granite, excluding earthenware articles	free	20	35
28705-1	Articles of chinaware, for mounting by silverware manufacturers	12½	17½	22½
28710-1	Undecorated tableware of china, porcelain, semi-porcelain for use in the manufacture of decorated tableware	free	10	35
28800-1	Stoneware and Rockingham ware and earthenware, nop	17½	20	35
28805-1	Chemical stoneware	free	10	35
28810-1	Hand forms of porcelain for manufacture of rubber gloves	free	free	35
28900-1	Baths, bathtubs, basins, closets, closet seats and covers, closet tanks, lavatories, urinals, sinks and laundry tubs of earthenware, stone, cement, clay or other material, nop	12½	20	35

Tariffs (Cont'd)
United States

Item No.		On and After January 1 1970	1971	1972
521.51	Fuller's earth, not beneficiated	10%	9%	7.5%
			(¢ per long ton)	
521.41	China clay or kaolin	46	40	33
521.54	Fuller's earth, wholly or partly beneficiated	70	60	50
521.81	Other clays, not beneficiated	20	10	free
521.84	Other clays, wholly or partly beneficiated	70	60	50
521.61	Bentonite	56	48	40
521.71	Common blue clay and other ball clays not beneficiated	50	46	42
521.74	Common blue clay and other ball clays, wholly or partly beneficiated	99	92	85
521.87	Clays artificially activated with acid or other material	0.07¢/lb + 8.5%	0.06¢/lb + 7%	0.05¢/lb + 6%

Sources: The Customs Tariff and Amendments, Department of National Revenue, Ottawa. Tariff Schedules of the United States, Annotated (1972) T.C. Publication, 452.
Note: In addition to the above tariffs various duties are in existence on manufactured clay products, viz., brick pottery, artware, etc.

Coking coal stacker at Fording Coal Limited's new mine situated 40 miles north of Sparwood in southeastern British Columbia. (George Hunter photo.)



Coal and Coke

L.P. CHRISMAS

The Canadian coal industry produced a record quantity of coal in 1971, surpassing the previous record of 19.1 million tons in 1950. Production of all types of coal, bituminous, subbituminous and lignite, increased 17 per cent to 19.4 million tons valued at $132 million. Value of production increased sharply in 1971, a 53 per cent increase over the 1970 value. Regionally, production increased in British Columbia, Alberta and New Brunswick and decreased in Saskatchewan and Nova Scotia. Exported coal, principally from western Canada to Japan, rose to a record 7.7 million tons, an increase of 75 per cent over 1970 exports. Canada is now firmly established as the third largest supplier of coal to Japan. Imported coal, all from the United States, was down slightly to 18.1 million tons, compared with 18.9 million tons in 1971. Domestic production in 1971 exceeded imports for the first time in more than thirty years. Coal consumption in Canada increased to an estimated 30 million tons in 1971 of which approximately 17.3 million tons were used to generate electrical power and 7.3 million tons were carbonized to produce 5.1 million tons of coke. Smaller amounts of coal were consumed by industrial and commercial users throughout Canada.

Outlook and forecast

The major growth in coal production in Canada to 1975 is predicated upon increased exports and consumption of coal for thermal electric power generation. Exports are estimated to increase at an average rate of 18 per cent annually and use in thermal plants at about 9 per cent.

Although exports to Japan in 1971 fell 2.1 million tons short of the contracted level of 9.5 million tons, it is expected that in 1972 producers will have completed modifications to facilities to correct initial technical problems and will begin to produce at contract levels. In 1972 exports to Japan should reach 12.4 million tons. Japan is now in an oversupply position for coking coal resulting from a decline in the growth of pig iron production and substantial improvements in the amount of coke required per ton of pig iron produced. As a result, in 1971 Japan cut back on coking coal imports from the United States and Australia. Although the Japanese steel industry is experiencing a slowing down from the spectacular increases earlier, steel industry representatives expect than an average annual growth rate of 8 per cent will be achieved over the next four years. At the same time, Japan in line with its policy of multiple supply sources for raw materials may allow some of the older coal contracts with United States producers to terminate without renewal and will tend to allow Canadian coal to assume a somewhat larger share of its market than it had in 1971. In early 1971 a number of Canadian coal companies were attempting to sign new coal contracts with Japan but by year-end none had been successful. Consequently in an effort to diversify markets some prospective coking coal producers in western Canada began to look for long-term sales in western Europe. In 1971 spot shipments of coal were made from western Canada to Italy, France and Belgium-Luxembourg. To date, most of the spot shipments have been thermal coal that is either byproduct coal or oxidized coal from certain sections of the coking coal mines. During the year, a few small shipments of coking coal were made to western Europe on an experimental basis.

Domestically, the use of coal for thermal power generation has a promising growth potential particularly in Alberta, Saskatchewan and Ontario. During the period 1960 to 1970, coal used for thermal electric power generation had an average annual

Table 1. Canada, coal production by types, provinces and territories, 1970-71

	1970		1971^p	
	(short tons)	($)	(short tons)	($)
Bituminous				
Nova Scotia	2,122,358	21,837,917	1,965,489	23,406,621
New Brunswick	395,642	2,964,478	517,209	4,169,781
Alberta	2,863,705	21,796,396	4,505,737	44,417,316
British Columbia and Yukon Territory	3,483,062	25,688,821	4,637,011	46,268,216
Total	8,864,767	72,287,612	11,625,446	118,261,934
Subbituminous				
Alberta	3,920,206	6,379,937	4,425,731	7,081,913
Lignite				
Saskatchewan	3,819,191	7,399,872	3,300,186	6,376,929
All types, Canada total	16,604,164	86,067,421	19,351,363	131,720,776

Source: Statistics Canada.
^{p}Preliminary.

Table 2. Canada, coal production, imports, exports and consumption, 1961-71

	Production	Imports	Exports	Domestic Demand
	(st)	(st)	(st)	(st)
1961	10,335,779	12,306,498	939,336	21,794,058
1962	10,216,618	12,614,189	893,919	22,419,224
1963	10,451,623	13,370,406	1,054,367	23,774,032
1964	11,219,311	14,989,114	1,291,664	24,731,197
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	4,391,575	29,757,279
1971^p	19,351,363	18,136,181	7,733,775	..

Source: Statistics Canada.
^{p}Preliminary. .. Not available.

growth rate of 23.5 per cent. Based on the utilities' plans for the next 5 to 10 years, use of coal for power generation is expected to grow at an average rate of about 9 per cent, increasing from 17.3 million tons in 1971 to about 24 million tons in 1975.

Production of all types of coal in Canada is expected to reach 24 million tons in 1972, an increase of about 25 per cent over 1971. By 1975, coal production in Canada is forecast to reach 30 million tons annually. For 1972 it is estimated that 13 million tons will be exported with about 12.4 million tons going to Japan and the remainder as spot shipments going to western Europe and the United States. Based on contracts now signed with Japan, export shipments should reach 14.4 million tons annually beginning in 1973 and continuing at least at this level through 1975. No allowance is made for spot shipments in this period or for new long-term contracts.

Although international market prospects for coal were not as bright at the end of the year as at the beginning, there is no question that a general upward trend will occur in world demand for coking and thermal coal in the longer term. This upward trend will likely be characterized by occasional oversupply and undersupply short-term conditions.

Production and mine developments

British Columbia. The most prolific coal-producing region in British Columbia, the Crowsnest Pass area, has large resources of low and medium volatile bituminous coal. This area which has been mined on a small scale since about 1898, is noted for its thick coal seams, which occur within faulted and disturbed Lower Cretaceous rocks. Isolated smaller coal basins in other parts of the province contain coal seams ranging in rank from lignite to anthracite.

Kaiser Resources Ltd., Canada's largest coal mine which began production in 1970, continued to have start-up difficulties through the first three quarters of 1971. After experiencing problems with its preparation plant and surface mine in 1970, Kaiser began a program of modification in 1971 to overcome these problems. This required additional capital expenditures estimated to be upwards of $30 million which would bring total capital costs to about $175 million. Because of these necessary modifications, Kaiser was able to negotiate interim adjustments to its 75 million long ton coal sales contract with Mitsubishi Corporation in Japan. This new agreement calls for the shipment to Japan of 4.4 million long tons during the adjustment period, fiscal year 1971-72. The original contract was for 5 million long tons annually. The new agreement also provided Kaiser with a special price increase and cost allowance which brought the price up to $18.65 a long ton fob Roberts Bank compared with $12.85 a long ton at the time the contract was originally signed in 1968. Negotiations for permanent contract revisions for the remainder of Kaiser's 15-year contract are expected to take place prior to July 1972. Towards the end of 1971 Kaiser was delivering coking coal at the rate and quality called for in the interim contract with the Japanese steel industry. However, a fire in its coal dryer curtailed coal shipments for 3 weeks in December.

On the technical side, Kaiser reported good results from its experimental underground hydraulic mine. In this mine, coking coal is cut at the faces by water jets under a pressure of 2,000 psi and sluiced in flumes to surface and down the hillside to a screening plant where the coal is dewatered. Although the hydraulic mine is considered a test facility, the current developmental program is capable of producing about 500,000 tons annually of coking coal.

At the end of 1971, Fording Coal Limited was in the final stage of construction of its surface coal mine, with official start-up scheduled for April 1, 1972. Fording plans to produce 2.5 million long tons of coking coal during its first year of operation and 3 million tons annually in subsequent years for the remainder of its 15-year contract with Japanese steel companies. Initially, coal will be mined from two locations in the area: Green Hill Mountain and at the Clode pit on the north end of Eagle Mountain. At Green Hill coal will be mined from three seams using a 60-cubic-yard dragline, the largest dragline in Canada. The Clode pit, where mining and stockpiling began in late 1971, is a truck and shovel operation. Preliminary tests at the Fording coal preparation plant were scheduled to begin in early January 1972 to provide a three-month break-in period prior to the formal contractual delivery date to allow time to overcome possible start-up problems.

Coal from Fording will be shipped in unit trains via a 34-mile railway spurline completed in October 1971, from the CPR mainline at Sparwood to the Fording mine. The coal will be trans-shipped at the Roberts Bank bulk loading port where additional equipment is being installed by Westshore Terminals Ltd. to also handle Fording coal. Fording is establishing a modern town for employees at Elkford, which is situated at the junction of the Fording and Elk Rivers about 30 miles via road north of Sparwood and 18 miles south of the mine site.

In 1971, a large number of companies continued to explore for coal in British Columbia. Specifically in northeastern British Columbia, the Sukunka coal property, originally owned exclusively by Brameda Resources Limited is now being explored by a consortium of five companies including Brameda. Nearby Denison Mines Limited was actively exploring the Babcock area of its Quintette project. At both the Sukunka and Babcock properties, the companies are nearing the stage where mining feasibility may be undertaken.

In southeastern British Columbia, the Line Creek property of Crows Nest Industries Limited, and the Elk River property of Scurry-Rainbow Oil Limited and its partner Emkay Canada Natural Resources Ltd. were undergoing mining feasibility studies. The owners of these properties continued their efforts to develop markets which will be necessary before the companies proceed to mine development.

Alberta. Most of Alberta's coal resources are of bituminous and subbituminous rank, but coal of all ranks from lignite to anthracite occur in the province. Subbituminous coal is found in the plains region whereas bituminous coal, much of which is of good coking quality, is located in the mountain and foothills belts. Alberta is Canada's leading coal-producing province and has the greatest number of coal mines, although many are small mines with production less than 25,000 tons a year. In the past when coal supplied a local market many of the small mines were forced to shut down because of competition from petroleum and natural gas. The current trend is to larger but fewer mines to meet the expanding market.

In Alberta, 20 coal mines operated in 1971, many of which were small mines producing subbituminous

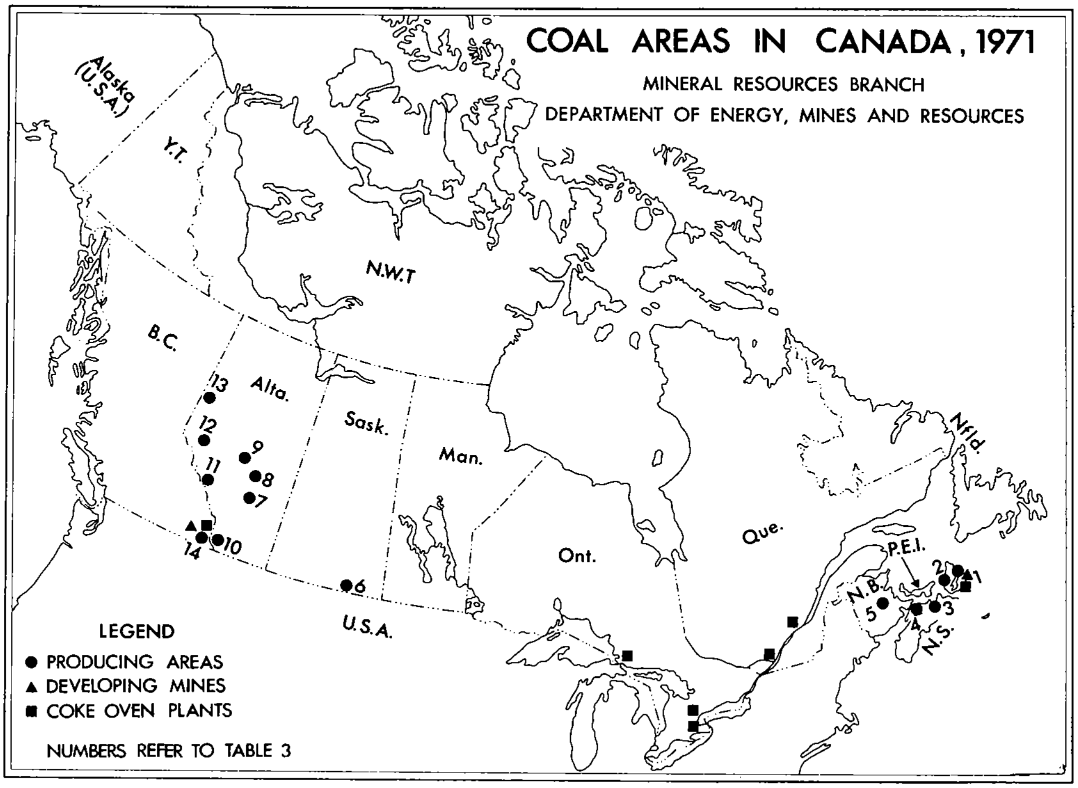


Table 3. Principal coal producers in 1971

Company and Location	Estimated Production	Coal Rank	Chief Markets	Remark
	(st)			
Nova Scotia				
1. Cape Breton Development Corporation, Sydney	1,750,000	Hvb	Thermal power, coke plant, industrial	Operates 3 underground collieries and coke oven plant. No. 20 colliery closed in 1971. Developing new mine at Lingan
2. Evans Coal Mines Limited, St. Rose	30,000	Hvb	Domestic, thermal power	Underground
3. Thorburn Mining Limited, Thorburn	100,000	Hvb	Industrial, thermal power	Underground phasing out operations
3. Drummond Coal Company Limited, Westville	34,000	Hvb	Thermal power	Underground
4. River Hebert Coal Company Limited, River Hebert	34,000	Hvb	Thermal power	Underground

Table 3. (cont'd)

Company and Location	Estimated Production	Coal Rank	Chief Markets	Remark
	(st)			
New Brunswick				
5. N.B. Coal Limited, Grand Lake	517,000	Hvb	Thermal power, industrial	Surface, underground mine closed in 1971
Saskatchewan				
6. Battle River Coal (Alberta Coal Ltd.), Estevan	585,000	Lig	Thermal power	Surface
6. Manitoba and Saskatchewan Coal Company (Limited) (Luscar Ltd.), Bienfait	550,000	Lig	Thermal power	Surface
6. Utility Coal Ltd. (Alberta Coal Ltd.), Estevan	2,100,000	Lig	Thermal power	Surface
Alberta				
Subbituminous mines				
7. Century Coals Limited, East Coulee	60,000	Sub	Domestic	Underground
8. Forestburg Collieries Limited, Forestburg	560,000	Sub	Thermal power	Surface
8. Battle River Coal, (a Division of Alberta Coal Ltd.), Halkirk	300,000	Sub	Thermal power	Surface
9. Alberta Coal Ltd., Wabamun				
Whitewood Mine	2,200,000	Sub	Thermal power	Surface
Highvale Mine	1,200,000	Sub	Thermal power	Surface
9. Star-Key Mines Ltd., St. Albert	24,000	Sub	Domestic	Underground
Bituminous mines				
10. Coleman Collieries Limited, Coleman	1,019,000	Mvb	Japan	Surface and underground, expanding capacity to 1.5 million tons annually
11. The Canmore Mines, Limited, Canmore	370,000	Lvb & An	Japan	Surface and underground
12. Cardinal River Coals Ltd., Luscar	1,000,000	Mvb	Japan	Surface
13. McIntyre Porcupine Mines Limited, Grande Cache	2,230,000	Lvb	Japan	Surface and underground, began a new surface mine in 1971
British Columbia				
14. Kaiser Resources Ltd., Natal	4,600,000	Lvb	Japan	Underground and surface
14. Fording Coal Limited, Elkford	–	Lvb	Japan	Surface production to begin April 1, 1972

An – Semianthracite; Lvb – Low volatile bituminous; Mvb – Medium volatile bituminous; Hvb – High volatile bituminous; Sub – Subbituminous; Lig – Lignite.

Table 4. Canada, coal production by type of mining and average output per man-day, 1971

	Production		Average Output per Man-day^p	
	Underground	Surface	Underground	Surface
	(st)	(st)	(st)	(st)
Nova Scotia	1,965,489	–	2.5	
New Brunswick	7,273	509,936	2.0	9.2
Saskatchewan	–	3,300,186	–	71.5
Alberta	2,702,065	6,229,403	8.3	40.9
British Columbia	658,787	3,978,224	5.5	16.3
Canada 1971^p	5,333,614	14,017,749	5.9	39.9
1970	4,621,594	11,282,570	4.9	50.4
Total, all mines 1971^p	19,351,363		30.6	
1970	16,604,164		37.7	

Source: Statistics Canada
^{p}Preliminary; –Nil.

coal for local markets. Only four mines produced coking coal, McIntyre Porcupine Mines Limited's coal operations at Grande Cache being the largest. McIntyre experienced start-up difficulties in the year with the result that its coal shipments to Japan fell substantially below the contracted quantity. McIntyre currently produces coal from two underground mines and one surface mine. The No. 2 and No. 5 underground mines, across the Smoky River valley from each other are the original sites that were designed for longwall mining. In June 1971, McIntyre announced that the longwall system of mining had been abandoned in these two mines and it was implementing a room-and-pillar mining method using continuous miners and shuttle cars. The failure of the longwall system is attributed to friable coal and weak roof conditions in both mines. With the abandonment of the longwall system coal output fell considerably below the 13,000 tons a day of raw coal that is required to meet the present contract commitments of 2 million tons of clean coal a year to Japan. In order to reach this level, the company had to develop the No. 8 surface mine to supplement underground production and, at the end of the year, combined production was reaching the contracted level.

In March 1971, McIntyre signed a tentative second contract with Japanese steel and gas companies for the delivery of 45.7 million long tons of coal over a 15-year period. However, at the end of 1971, the contract had not been finalized.

The new coking coal mine of Cardinal River Coals Ltd. operated at full capacity in 1971 and shipped about 1.0 million tons of coking coal to Japan. During the year the company announced that it is seeking markets to increase production from 1.0 million to 1.5 million long tons a year.

In 1971 controlling interest of Coleman Collieries Limited, a coking coal producer in southern Alberta, was obtained by Northern and Central Gas Corporation Limited of Toronto when it purchased Hillcrest Collieries, Limited and Byron Creek Collieries Limited which together held an 82 per cent interest in Coleman. In 1970, Coleman announced the signing of an additional export contract to Japan for 5 million long tons, which is to be delivered during a 10-year period beginning in 1972. Based on signed contracts, Coleman will produce an estimated 1.5 million long tons a year of coking coal beginning January 1, 1972.

Exploration for coking and steam coal in Alberta continued but at a higher pace in 1971 than in 1970. Of the numerous coal properties that were explored in 1971, the Gregg River property near Luscar owned by Master Explorations Ltd. (a subsidiary of Alberta Coal Ltd.) completed a mining feasibility study and was investigating markets for up to 2 million tons annually of coking coal. Other companies that were actively exploring in Alberta included Canpac Minerals Limited, McIntyre Porcupine Mines Limited, Denison Mines Limited, Consolidation Coal Company of Canada, Mill City Petroleums Limited, Coleman Collieries Limited, The Canmore Mines, Limited, Scurry-Rainbow Oil Limited, Woods Petroleum of Canada, Ltd. and Rio Tinto Canadian Exploration Limited.

Subbituminous production continued to expand during 1971 because of the growing demand for coal for mine-mouth, thermal power plants in Alberta. Additional expansion of subbituminous production is expected in the Wabamun area where the new Highvale mine operated by Alberta Coal Ltd. for Calgary Power Ltd., is located. The present capacity of 1.2 million tons a year at the Highvale mine will be

Table 5. Regional Canadian coal shipments, 1971

	Originating Province					
Destination	Nova Scotia	New Brunswick	Saskatchewan	Alberta	British Columbia and Yukon	Canada
	(st)	(st)	(st)	(st)	(st)	(st)
Railways in Canada	10,978	–	119,048	1,021	137	131,184
Newfoundland	7,197	–	–	–	–	7,197
Prince Edward Island	16,570	–	–	–	–	16,570
Nova Scotia	1,487,523	43,541	–	–	–	1,531,064
New Brunswick	35,835	319,424	–	–	–	355,259
Quebec	189,580	84,210	–	360	–	274,150
Ontario	192,881	94	135,553	33,182	–	361,710
Manitoba	–	–	681,475	90,478	–	771,953
Saskatchewan	–	–	2,357,850	32,951	–	2,390,801
Alberta	–	–	–	4,279,029	–	4,279,029
British Columbia	–	–	–	65,183	293,472	358,655
Total, Canada	1,940,564	447,269	3,293,926	4,502,204	293,609	10,477,572
United States	–	–	8,976	5,926	754	15,656
Japan	–	–	–	3,339,404	4,063,778	7,403,182
Other	–	–	–	93,151	207,578	300,729
Total shipments	1,940,564	447,269	3,302,902	7,940,685	4,565,719	18,197,139

Source: Statistics Canada. – Nil.

doubled as new units to use the coal are added to the Sundance electric power station. The other chief area of expanding subbituminous production is at Forestburg, where two mines will increase production to meet the planned 150-megawatt expansion to the Battle River power station, which will require an estimated additional 700,000 tons of subbituminous coal annually.

Saskatchewan. In the Estevan area of southeastern Saskatchewan, lignite is strip mined at three highly productive mining operations by Manitoba and Saskatchewan Coal Company (Limited), a Luscar Ltd. subsidiary and two Alberta Coal Ltd. subsidiaries – Utility Coals Ltd. and Battle River Coal. The shallow lignite seams are part of a field extending from southern Saskatchewan into North Dakota, South Dakota and Montana. The Saskatchewan lignite mines have the highest productivity in Canadian coal mining with an average output of 71.5 tons per man per day. In part, this reflects the nature of the coal occurrences at Estevan, which have shallow overburden and are fairly thick coal seams that can be mined efficiently by large dragline and shovel operations.

In 1971, production of Saskatchewan lignite declined slightly in contrast to output in 1970, which was a record year. This was predictable because in 1970 more than 500,000 tons of lignite were shipped to power plants in Ontario because of shortages of imported coal and in 1971 shipments to Ontario returned to about the normal level of 125,000 tons. The future for Saskatchewan lignite appears to be excellent based on the growth of the thermal power industry in the province. In this respect, a joint federal-provincial coal exploration program will begin in 1972 to assess the lignite resources in greater detail.

New Brunswick. In New Brunswick coal is mined within the Minto coalfield where only one coal seam has been mined in recent years. The flat-lying seam has an average thickness of only two feet and is covered by overburden ranging from 35 to 80 feet. In the past, coal was mined by both underground and surface methods. However, in 1971 the last remaining underground mine was closed and the employees were absorbed into the surface mining operations. After a period of decline, from 1 milion tons in 1964 to about 395,000 tons in 1970, production increased in 1971 to about 500,000 tons. Increased demand for local thermal power generation by the provincial utility company contributed primarily to this upsurge. Also the surface coal mines are more efficient after being consolidated into one operation under the provincially owned corporation, N.B. Coal Limited.

Nova Scotia. High volatile bituminous coal is produced mainly from mines at Sydney, on Cape Breton Island, with some output from the Inverness area also on

Cape Breton, and Pictou and Joggins areas on the mainland. The coalfields in Nova Scotia, many of which are submarine, are of Carboniferous age and contain the oldest coal measures produced in Canada. Some of the Sydney area coal makes satisfactory coke, which is one of the chief markets for Nova Scotia Coal, along with thermal power generation plants.

Nova Scotia coal production declined slightly in 1971 to about 2.0 million tons. During the year two coal mines were closed. The Cape Breton Development Corporation stopped production at its No. 20 colliery and employees were transferred to the other three collieries owned by the corporation and the new Lingan mine currently under development. The No. 20 colliery was closed for an indefinite period pending a review of the economic viability and safety of the mine. Work is proceeding rapidly on two of the four deeps planned for Cape Breton Development Corporation's new mine at Lingan scheduled for opening in 1974. In Springhill, Nova Scotia, Springhill Coal Mines Limited closed its mine because of flooding conditions. The McBean Colliery, owned by Thorburn Mining Limited is scheduled to close in early 1972. In 1971 the federal government provided a $750,000 grant to offset losses during the phase-out period and to reclaim the mine site.

Trade and markets

Within Canada the prime markets for coal now are the thermal electric power industry and the iron and steel industry. Apparent consumption in Canada in 1971 was 29.7 million tons. Since 1961, the general trend of coal consumption in Canada has been upwards based primarily on the expanding use of coal in thermal electric plants and to a lesser extent on coal for metallurgical coke. In the last 10 years, markets for coal within Canada have changed substantially. Thermal power plants, which used about 6 per cent of total coal consumption in 1960, used 50 per cent in 1970. The coke industry remains a substantial market using roughly 27 per cent of all coal consumed in Canada.

Exports. A total of 7.7 million tons of bituminous coal having a value of $86.5 million was exported in 1971 to seven countries. Japan received 95 per cent or 7.4 million tons of Canadian coal in 1971 as compared to 4.1 million tons in 1970. This tonnage which is part of long-term contracts represents 14.4 per cent of Japan's total coal imports during 1971. All coal shipped to Japan was of coking quality whereas spot shipments of about 300,000 tons of steam coal were made to four countries in western Europe. These were Italy, France, Belgium-Luxembourg and Britain. Italy received approximately 50 per cent of the shipments made to western Europe. Exports to the United States continued to decline in 1971.

Of the 7.7 million tons exported in 1971, 55 per cent originated in British Columbia and 45 per cent in Alberta. A small quantity of lignitic coal was exported

Table 6. Canada, exports and imports of coal, 1970-71

	1970		1971^p	
	(short tons)	($)	(short tons)	($)
Exports				
Bituminous				
Japan	4,123,343	35,000,000[1]	7,407,898	82,063,000
Italy	23,931	312,000	155,851	2,440,000
France	25	–	73,332	825,000
Belgium-Luxembourg	92,922	1,029,000	66,069	755,000
United Kingdom	–	–	19,602	359,000
United States	150,361	1,346,000	10,614	112,000
St. Pierre	805	12,000	409	9,000
India	188	11,000	–	–
Total	4,391,575	37,710,000	7,733,775	86,563,000
Imports (for consumption)				
Anthracite				
United States	353,444	5,233,162	404,231	6,124,000
Bituminous				
United States	18,510,335	145,156,981	17,731,950	144,889,000
Total all types	18,863,779	150,390,143	18,136,181	151,013,000

Source: Statistics Canada.
^{p}Preliminary; – Nil. [1]Recalculated by Mineral Resources Branch.

Table 1 (concl'd)

	1970		1971p	
	(short tons)	($)	(short tons)	($)
Br. Honduras	18	18,000	271	388,000
Puerto Rico	605	1,353,000	181	369,000
U.S. Virgin Islands	73	169,000	165	300,000
Other countries	3,793	6,278,000	3,237	4,321,000
Total	34,878	66,461,000	18,224	32,604,000
Total exports of copper and products	. .	803,801,000	. .	636,878,000
Imports				
Copper in ores, concentrates, scrap	7,362	5,556,000	21,645	16,030,000
Copper refinery shapes	14,542	18,789,000	21,894	22,369,000
Copper bars, rods and shapes, nes	500	621,000	487	551,000
Copper plates, sheet, strip and flat products	347	737,000	619	1,060,000
Copper pipe and tubing	1,282	2,518,000	3,122	4,765,000
Copper wire and cable, except insulated	206	420,000	182	360,000
Copper alloy scrap (gross weight)	3,771	3,093,000	3,991	2,737,000
Copper powder	264	498,000	353	546,000
Copper alloy refinery shapes, rods and sections	5,480	6,954,000	7,475	8,006,000
Brass plates, sheet, strip and flat products	2,105	3,184,000	3,864	4,648,000
Copper alloy pipe and tubing	1,184	2,517,000	1,492	2,620,000
Copper alloy wire and cable, except insulated	294	850,000	558	1,059,000
Copper alloy castings	337	733,000	262	526,000
Copper and alloy fabricated materials, nes	951	1,816,000	995	1,599,000
Insulated wire and cable	. .	10,277,000	. .	11,670,000
Copper oxides and hydroxides	212	317,000	197	247,000
Copper sulphate	2,268	941,000	2,003	801,000
Total imports of copper and products	. .	59,821,000	. .	79,594,000
Consumption[3]				
Refined	237,838	. .	221,053	. .

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.
pPreliminary; – Nil; . . Not available; nes Not elsewhere specified; . . . Less than 1,000 lb.

Canadian supply and demand

Mine production. Ten new copper-producing mines were placed in production in 1971 and ten mines were closed, resulting in a net increase in annual productive capability of about 40,000 tons of contained copper. Strikes and labour difficulties had a minor effect on Canadian copper production in 1971. The Buchans, Newfoundland, unit of American Smelting and Refining Company, was closed for over four months by a walkout; the Flin Flon and Snow Lake operations of Hudson Bay Mining and Smelting Co., Limited were on strike from January 27 to June 21; and Campbell Chibougamau Mines Ltd. was struck at year-end. The industry may experience more serious problems in 1972, however, as labour contracts in the Sudbury nickel-copper mines expire around midyear.

During 1971 The International Nickel Company of Canada, Limited (Inco) cut back its output of nickel by 22 per cent in two stages. It is not expected that Inco's output of copper will be lowered appreciably by this cutback in nickel production.

Twelve new mines are scheduled to begin operations in 1972 and five are expected to cease production. These changes should result in a 1972

Table 2. Canada, copper production, trade and consumption, 1962-71

	Production		Exports			Imports, Refined	Consumption[2], Refined
	All Forms	Refined	Ore and Matte	Refined	Total		
	(short tons)						
1962	457,385	382,868	89,374	223,043	312,417	147	151,525
1963	452,559	380,075	92,930	214,987	307,917	6,549	169,750
1964	486,900	407,942	104,550	224,273	328,823	6,771	202,225
1965	507,877	434,133	87,000	199,830	286,830	5,747	224,684
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[r]	157,816	210,034	367,850	18,137	226,281[r]
1970	672,717	543,071	179,119	292,403	471,522	14,542	237,838
1971[p]	714,507	526,401	224,858	312,363	537,221	21,894	221,053

Source: Statistics Canada.
[1]Blister copper plus recoverable copper in matte and concentrates exported. [2]Producers' domestic shipments, refined copper.
[p]Preliminary; [r]Revised.

productive capability of about 837,000 tons of copper in concentrates. However, because of start-up difficulties and unscheduled shutdowns, production in 1972 is expected to be about 800,000 tons.

Information pertaining to individual mines can be obtained from the accompanying tables. Table 3 lists all mines that produced copper in 1970 and 1971 along with production statistics and a brief description of events that occurred in 1971. The statistics used have been largely obtained directly from each company. Table 4 lists the mines for which production plans have been announced. Table 5 lists some properties that are actively being explored and may become producers in the near future.

Metal production. A comprehensive summary of the six Canadian smelters that treat copper-bearing materials is given in Table 6. Output of blister copper at the Flin Flon smelter of Hudson Bay Mining and Smelting Co., Limited was seriously curtailed by the five-month strike that occurred there. Operations at other smelters were normal. Inco announced that the Coniston smelter would be closed down in April, 1972 as part of that company's retrenchment program.

The operations of the two Canadian copper refineries are summarized in Table 7.

Construction was under way on the major smelter and refinery expansion program of Noranda Mines Limited, scheduled for completion in 1973. At Gaspé, smelter capacity will be raised to produce an additional 27,000 tons of anode copper a year. The size of the sulphuric acid plant being built has been increased to 300,000 tons a year. Some of this acid will be used to leach copper from low-grade oxide ores. At Noranda, the smelter is being expanded by the construction of a Noranda Continuous Smelting Process reactor capable of producing 55,000 tons a year of blister copper in one furnace directly from concentrates. This will be the first such smelter in commercial production in the world. The development of the process was carried out by Noranda's own research and operating staffs. In line with these smelter increases, Noranda is expanding its copper refinery at Montreal East by about 80,000 tons of annual capacity of refined copper. It is anticipated that this expansion can be accomplished, without increasing the number of electrolytic cells, by changing over to a periodic current reversal form of electrodeposition.

Four companies sell refined copper in Canada. They are Noranda Mines Limited, The International Nickel Company of Canada, Limited (Inco), Texas Gulf Sulphur Company, and Hudson Bay Mining and Smelting Co., Limited. Noranda sells copper that it produces from concentrates obtained from its own and affiliated companies, from concentrates shipped on a custom basis, and from scrap. Inco sells copper produced from its nickel-copper mines at Sudbury, Ontario, and Thompson, Manitoba. Texas Gulf produces copper concentrates at its Ecstall mine at Timmins, Ontario; these are smelted and refined by Noranda on a toll basis. Noranda also toll refines blister copper from the Hudson Bay smelter at Flin Flon, Manitoba. (*Text continued on page 19.*)

Table 3. Producing copper mines in Canada, 1971 and [1970]

Company and Location	Mill or Mine Capacity	Grade of Ore: Copper	Grade of Ore: Zinc	Grade of Ore: Nickel	Grade of Ore: Silver	Ore Produced	Contained Copper Produced	Remarks
	(tons ore/day)	(%)	(%)	(%)	(oz/ton)	(tons)	(tons)	
Newfoundland								
American Smelting and Refining Company, Buchans	1,250 [1,250]	1.08 [1.11]	12.39 [12.68]	– –	3.71 [3.73]	173,000 [359,000]	1,698 [3,700]	Production halted by strike from June 21 to Nov. 12, 1971.
British Newfoundland Exploration Limited, Whalesback mine, Springdale	2,000 [2,000]	0.78 . .	– –	– –	– –	. . . .	3,890 . .	Mine to be closed in mid-1972.
Consolidated Rambler Mines Limited, Baie Verte	1,500 [1,200]	1.12 [0.79]	– –	– –	0.08 . .	429,351 [418,447]	4,730 [3,191]	Developed new Ming mine.
First Maritime Mining Corporation Limited, Gullbridge mine, Badger	2,500 [2,500]	0.62 [0.70]	– –	– –	– –	693,607 [723,715]	4,012 [4,675]	Mine closed Dec. 5, 1971 because of declining copper prices.
Nova Scotia								
Dresser Minerals, Division of Dresser Industries, Inc., Walton	140 [140]	0.36 [0.33]	0.50 [0.50]	– –	4.35 [3.58]	16,125 [27,263]	53 [89]	
New Brunswick								
Anaconda American Brass Limited, Caribou mine, Restigouche Co.	850 [1,000]	3.83 . .	1.90 . .	– –	. . . .	154,995 [3,000]	2,706 [53]	Operations closed Nov. 1971 due to metallurgical difficulties in producing marketable concentrates.
Brunswick Mining and Smelting Corporation Limited, Bathurst No. 6 mine	3,500 [3,500]	0.36 [0.33]	5.76 [5.86]	– –	1.86 [1.84]	1,300,946 [1,100,703]	1,967 [28]	Mill circuits redesigned to produce separate lead and zinc concentrates.

Table 3 (cont'd)

Company and Location	Mill or Mine Capacity	Grade of Ore: Copper	Zinc	Nickel	Silver	Ore Produced	Contained Copper Produced	Remarks
	(tons ore/day)	(%)	(%)	(%)	(oz/ton)	(tons)	(tons)	
No. 12 mine	6,000 [6,000]	0.30 [0.32]	8.11 [7.54]	– –	2.44 [2.19]	1,567,352 [1,519,981]	2,648 [2,200]	Mining methods being changed to predominantly mechanized cut-and-fill stoping.
Heath Steele Mines Limited, Newcastle	3,000 [3,000]	0.97 [0.97]	5.29 [5.40]	– –	2.21 [2.20]	972,456 [1,030,899]	6,190 [6,453]	Plan to sink No. 5 shaft in "B" zone. May expand milling rate to 4,000 tpd by 1976.
Nigadoo River Mines Limited, Robertville	1,000 [1,000]	0.27 [0.32]	2.66 [2.63]	– –	3.37 [3.59]	322,956 [319,689]	746 [677]	Production halted by strike on Nov. 22, 1971. Operations suspended indefinitely Jan. 4, 1972.
Quebec								
Bell Allard Mines Limited, Matagami	– [900]	– [0.58]	– [9.26]	– –	– [1.11]	– [61,265]	– [281]	Open-pit operation terminated in Nov. 1971. Controlled by Orchan mines.
Campbell Chibougamau Mines Ltd., Cedar Bay, Henderson Kokko Creek, and Original mines, Chibougamau	4,000 [4,000]	1.52 [1.55]	– –	– –	0.27 [0.28]	1,294,285 [1,309,718]	17,957 [18,492]	
Delbridge Mines Limited, Noranda	500 [500]	0.45 [0.71]	8.62 [10.29]	– –	2.86 [3.48]	154,172 [196,844]	678 [1,217]	Ore trucked to Quemont mill. Operations closed Sept. 2, 1971 due to exhaustion of ore reserves.
Falconbridge Copper Limited, Lake Dufault Division (formerly Lake Dufault Mines Limited), Noranda	1,500 [1,300]	1.48 [1.36]	2.02 [1.82]	– –	0.60 [0.53]	509,095 [419,171]	7,331 [5,558]	Production from Millenbach mine commenced Nov. 1, 1971. To sink internal shaft at Millenbach mine.
Opemiska Division (formerly Opemiska Copper Mines (Quebec) Limited, Chapais	3,000 [3,000]	2.31 [2.46]	– –	– –	0.31 [0.33]	1,074,047 [835,942]	23,706 [19,662]	Installing on-stream X-ray analyzer and computer control system in mill.

Table 3 (cont'd)

Company and Location	Mill or Mine Capacity	Grade of Ore: Copper	Grade of Ore: Zinc	Grade of Ore: Nickel	Grade of Ore: Silver	Ore Produced	Contained Copper Produced	Remarks
	(tons ore/day)	(%)	(%)	(%)	(oz/ton)	(tons)	(tons)	
Gaspé Copper Mines, Limited, Murdochville	11,000 [11,000]	0.91 [0.95]	– –	– –	– –	3,980,525 [4,070,853]	32,717 [35,040]	Mill capacity to be expanded to 34,000 tpd by 1973. Will also vat leach 5,000 tpd of oxide ore.
Icon Sullivan Joint Venture, (formerly Icon Syndicate) Chibougamau	650 [650]	2.95 [2.83]	– –	– –	. . [0.19]	221,496 [219,764]	6,526 [6,046]	Diverted river to expand both open-pit and underground mining in No. 2 area.
Joutel Copper Mines Limited, Joutel	700 [700]	2.24 [2.17]	– –	– –	– –	239,201 [246,760]	4,988 [5,361]	Ore trucked to Mines de Poirier mill. Mining of copper ore to cease in Aug. 1972. Will then mine zinc ore from new production zone.
Louvem Mining Company Inc., Louvicourt	800 [800]	2.13 [2.76]	– –	– –	0.34 [0.50]	279,502 [98,910]	5,724 [2,644]	Ore trucked to Manitou-Barvue mill. Mining switched to underground in June, 1971.
Madeleine Mines Ltd., Gaspé Provincial Park	2,500 [2,500]	1.38 [1.26]	– –	– –	. . [0.30]	869,467 [848,570]	11,246 [9,868]	Preparing to sink a 1,000-foot winze from 2,900 level.
Manitou-Barvue Mines Limited, Val-d'Or	1,600 [1,600]	. . [0.59]	1.96 [2.19]	– –	4.42 [4.66]	225,915 [362,170]	52 [524]	Mine closed temporarily Oct. 29, 1971. Mills ore from Louvem on custom basis.
Mattagami Lake Mines Limited, Matagami	3,850 [3,850]	0.62 [0.59]	9.30 [9.10]	– –	1.07 [0.86]	1,386,160 [1,430,864]	7,232 [7,182]	Completed installing second underground crusher and conveyor.
New Hosco Mines Limited, Matagami	– [900]	– [0.94]	– [0.76]	– –	– [0.38]	– [64,248]	– [515]	Production ceased April 1970 as reserves exhausted.
Noranda Mines Limited, Horne Division Noranda	3,000 [3,000]	2.24 [2.01]	– –	– –	0.43 [0.41]	682,618 [654,262]	14,657 [12,572]	Ore reserves expected to be exhausted by end of 1973.
Normetal Mines Limited, Normetal	1,000 [1,000]	1.76 [1.77]	5.74 [6.72]	– –	1.50 [1.47]	335,298 [348,100]	5,534 [5,777]	Ore reserves expected to be exhausted by mid-1973.
Orchan Mines Limited, Matagami	2,000 [1,900]	0.93 [1.03]	10.66 [11.10]	– –	1.27 [1.36]	409,492 [414,521]	3,136 [3,483]	

Table 3 (cont'd)

Company and Location	Mill or Mine Capacity	Grade of Ore: Copper	Zinc	Nickel	Silver	Ore Produced	Contained Copper Produced	Remarks
	(tons ore/day)	(%)	(%)	(%)	(oz/ton)	(tons)	(tons)	
Patino Mines (Quebec) Limited (formerly The Patino Mining Corporation, Copper Rand Mines Division), Copper Rand, Copper Cliff, Jaculet, and Portage mines, Chibougamau	2,800 [3,000]	1.94 [1.98]	– –	– –	0.21 [0.21]	992,401 [837,187]	18,472 [15,931]	Shaft deepening for six new levels completed at Portage mine.
Quemont Mines Limited, Noranda	2,400 [2,400]	0.78 [0.78]	2.06 [1.89]	– –	1.03 [0.91]	332,916 [299,636]	2,361 [2,077]	Mining and milling ceased Nov. 11, 1971 as ore reserves exhausted.
Renzy Mines Limited, Hainault Township	1,000 [1,000]	0.55 [0.51]	– –	0.43 [0.46]	– –	314,630 [324,015]	1,437 . .	Smelter contract to be cancelled effective April 4, 1972.
Rio Algom Mines Limited, Mines de Poirier mine, Joutel	2,500 [2,500]	2.61 [2.30]	– –	– –	– –	613,603 [561,559]	15,095 [12,338]	Mills ore from Joutel Copper Mines.
Sullivan Mining Group Ltd., Cupra and D'Estrie Divisions Stratford Centre	1,400 [1,400]	2.22 [1.78]	3.35 [2.95]	– –	1.02 [1.14]	218,169 [375,447]	4,409 [6,108]	
Weedon Mines Division, Stratford Centre		1.44 –	0.85 –	– –	0.32 –	181,037 –	2,422 –	Ore trucked to Cupra mill. Shaft deepened 500 feet to open two new levels.
Ontario								
Canadian Jamieson Mines Limited, Timmins	550 [575]	1.33 [1.77]	2.14 [3.07]	– –	– –	20,567 [207,885]	248 [3,328]	Mining and milling ceased Feb. 12, 1971 as ore reserves exhausted.
Consolidated Canadian Faraday Limited, Werner Lake	1,100 [1,100]	0.35 . .	– –	0.83 . .	– –	99,731 [105,504]	307 [326]	Mills ore from Dumbarton Mines. Reserves declining.
Copperfields Mining Corporation Limited, Timagami	200 [200]	5.88 [3.98]	– –	– –	0.36 . .	53,108 [50,271]	3,061 [2,002]	Operations expected to cease early in 1972 due to exhaustion of ore reserves.

Table 3 (cont'd)

Company and Location	Mill or Mine Capacity	Grade of Ore: Copper	Grade of Ore: Zinc	Grade of Ore: Nickel	Grade of Ore: Silver	Ore Produced	Contained Copper Produced	Remarks
	(tons ore/day)	(%)	(%)	(%)	(oz/ton)	(tons)	(tons)	
Ecstall Mining Limited, Kidd Creek mine, Timmins	10,000 [10,000]	.. ..	.. ..	– –	.. ..	3,673,350 [3,584,124]	46,520 [44,583]	Shaft completed. Preparations for underground mining under way.
Falconbridge Nickel Mines Limited, East, Falconbridge, Fecunis, Hardy, Longvac South, Manibridge, North, Onaping and Strathcona mines, Falconbridge	14,100 [14,100]	.. ..	– –	.. ..	.. ..	4,703,000 [4,631,000]	30,492[d] [28,461][d]	Development work on new properties slowed down due to slack market for nickel.
The International Nickel Company of Canada, Limited Clarabelle, Coleman, Copper Cliff North, Copper Cliff South, Crean Hill, Creighton, Frood-Stobie, Garson, Kirkwood, Levack, Little Stobie, Maclennan, Murray and Totten mines, Copper Cliff	76,600 [70,500]	.. ..	– –	.. ..	.. ..	21,847,700 [22,996,100]	170,150[d] [174,050][d]	Production of nickel reduced by 22% due to slack market for nickel.
Jameland Mines Limited, Timmins	700 [700]	1.29 [1.35]	1.95 [0.28]	– –	– –	156,586 [191,810]	1,634 [2,112]	Ore trucked to Kam-Kotia mill. Ore reserves limited.
Kam-Kotia Mines Limited, Timmins	2,500 [2,500]	0.78 [0.78]	2.51 [2.78]	– –	.. ..	480,145 [650,869]	3,047 [4,128]	Mills ore from Jameland.
McIntyre Porcupine Mines Limited, Schumacher	2,200 [2,200]	0.67 [0.75]	– –	– –	0.11 [0.12]	773,250 [751,830]	4,826 [5,223]	
Noranda Mines Limited, Geco Division, Manitouwadge	5,000 [5,000]	2.27 [1.86]	5.52 [3.89]	– –	2.03 [1.82]	1,759,952 [1,366,176]	37,656 [23,840]	

Table 3 (cont'd)

Company and Location	Mill or Mine Capacity	Grade of Ore: Copper	Grade of Ore: Zinc	Grade of Ore: Nickel	Grade of Ore: Silver	Ore Produced	Contained Copper Produced	Remarks
	(tons ore/day)	(%)	(%)	(%)	(oz/ton)	(tons)	(tons)	
North Canadian Enterprises Limited, Coppercorp mine, Port Mamainse	500 [500]	1.26 [1.32]	– –	– –	– –	156,111 [140,830]	1,903 [1,800]	
Rio Algom Mines Limited, Pronto Division, Spragge	– [750]	– [1.72]	– –	– –	– –	– [57,154]	– [950]	Mine closed April 30, 1970 as ore reserves exhausted.
Selco Mining Corporation Limited, South Bay Division, Uchi Lake	500 –	2.33 –	13.29 –	– –	. . –	130,019 –	2,766 –	Production started March 1971.
Tribag Mining Co., Limited Batchawana Bay	500 [500]	1.47 [2.06]	– –	– –	. . . .	191,725 [173,270]	2,722 [3,493]	Underground exploration continuing.
Upper Beaver Mines Limited, Dobie	300 [300]	1.45 [1.44]	– –	– –	. . [0.14]	88,390 [65,548]	1,280 [906]	Production to cease in Jan. 1972.
Willroy Mines Limited, (includes Willecho and Big Nama Creek), Manitouwadge	1,600 [1,600]	0.89 [0.85]	3.33 [4.02]	– –	1.36 [1.99]	427,589 [388,005]	3,511 [3,504]	Production from Big Nama Creek suspended Sept. 1971. New ore being developed at depth at Willroy mine.
Manitoba								
Dumbarton Mines Limited, Bird River	800 [700]	0.32 . .	– –	0.86 . .	– –	299,480 [252,552]	867 [761]	
Falconbridge Nickel Mines Limited, Manibridge mine, Wabowden	1,000 –	–	–	See Ontario –	–	–	–	Production started in 1971.
Hudson Bay Mining and Smelting Co., Limited, Anderson, Chisel, Dickstone, Flin Flon, Osborne, Schist, and Stall Lake mines, Flin Flon and Snow Lake	7,500 [7,500]	2.80 [2.67]	3.20 [3.94]	– –	0.50 [0.61]	1,084,000 [1,709,130]	28,917 [45,767]	Plants shut down by strike Jan. 27 to June 21, 1971. Includes Saskatchewan production.

Table 3 (cont'd)

Company and Location	Mill or Mine Capacity	Grade of Ore: Copper	Zinc	Nickel	Silver	Ore Produced	Contained Copper Produced	Remarks
	(tons ore/day)	(%)	(%)	(%)	(oz/ton)	(tons)	(tons)	
The International Nickel Company of Canada, Limited, Brichtree, Pipe, Soab and Thompson mines, Thompson	18,400 [18,400]	.. ..	– –	.. ..	– –	4,776,678 [3,861,700]	170,150[d] [174,050][d]	
Sherrit Gordon Mines, Limited, Lynn Lake mine, Lynn Lake	3,500 [3,500]	0.41 [0.51]	– –	0.66 [0.77]	– –	1,158,000 [1,090,000]	4,055 [5,010]	Deepening of Farley mine by driving a decline continuing.
Fox Lake mine, Lynn Lake	3,000 [3,000]	2.86 [3.07]	1.54 [1.13]	– –	– –	1,022,000 [389,000]	27,519 [10,273]	Full production rate reached in 1971.
Saskatchewan								
Hudson Bay Mining and Smelting Co., Limited Flexar and Flin Flon mines, Flin Flon				See Manitoba				
Rio Algom Mines Limited, Anglo-Rouyn mine, La Ronge	900 [900]	1.52 [1.68]	– –	– –	0.19 [0.22]	309,489 [314,902]	4,246 [4,885]	Production expected to end July, 1972 when ore reserves will be exhausted.
British Columbia								
Anaconda Britannia Mines Ltd., Britannia Beach	3,000 [3,000]	1.17 ..	– ..	– –	.. –	720,964 [320,642]	7,962 [2,735]	
Bethlehem Copper Corporation Ltd., Heustis and Jersey mines Highland Valley	15,000 [15,000]	0.52 [0.51]	– –	– –	– –	5,625,999 [5,450,746]	25,350 [24,221]	Plans under way to start stripping the Iona orebody.
Brenda Mines Ltd. Peachland	24,000 [24,000]	0.21 [0.22]	– –	– –	– –	8,987,210 [7,326,559]	17,082 [14,311]	
Churchill Copper Corporation Ltd., Magnum mine, Fort Nelson	750 [750]	3.32 [3.20]	– –	– –	– –	177,096 [171,277]	5,905 [5,291]	Operations suspended Oct. 1, 1971, because of low copper prices.

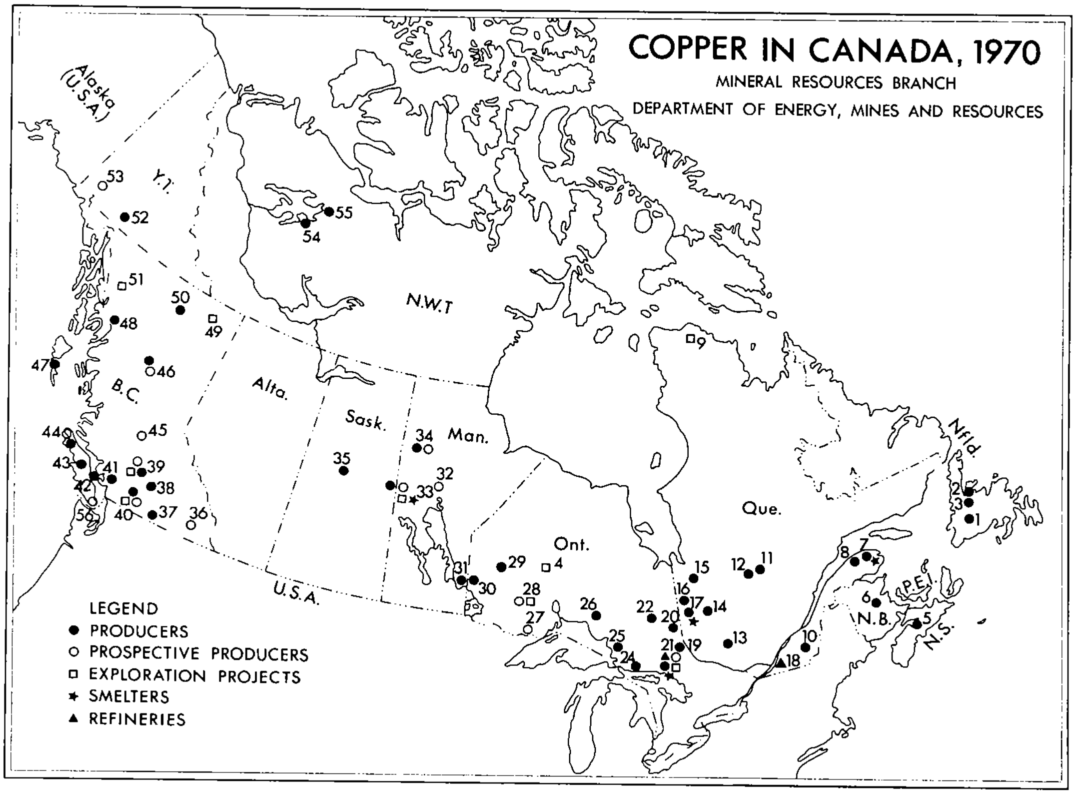
Table 3 (cont'd)

Company and Location	Mill or Mine Capacity	Grade of Ore: Copper	Zinc	Nickel	Silver	Ore Produced	Contained Copper Produced	Remarks
	(tons ore/day)	(%)	(%)	(%)	(oz/ton)	(tons)	(tons)	
Cominco Ltd., Coast Copper mine, Benson Lake, V.I.	750 [750]	1.97 2.02	– –	– –	– –	295,684 [290,911]	5,533 [5,757]	
Craigmont Mines Limited, Merritt	5,000 [5,000]	1.15 [1.03]	– –	– –	– –	1,827,864 [1,797,213]	19,661 [17,055]	
Falconbridge Nickel Mines Limited, Wesfrob mine, Tasu Harbour, Q.C.I.	8,000 [8,000]	0.70 [0.81]	– –	– –	– –	996,471 [1,200,000]	6,797 [9,142]	Copper concentrate produced as byproduct of iron mining and beneficiation.
Giant Mascot Mines Limited, Hope	1,750 [1,500]	0.39 [0.43]	– –	0.77 [0.84]	– –	260,241 [211,460]	983 [749]	New concentrator started May 14, 1971.
The Granby Mining Company Limited, Granisle mine, Babine Lake	6,500 [6,500]	0.56 [0.55]	– –	– –	– –	2,288,952 [2,393,161]	11,663 [11,396]	Production expansion to 14,000 tpd scheduled for Sept. 1972.
Phoenix Copper Division, Greenwood	2,400 [2,400]	0.79 [0.77]	– –	– –	0.24 [0.24]	902,325 [862,156]	6,345 [5,733]	
Granduc Operating Company, Stewart	7,500 [7,000]	1.31 [1.32]	– [0.23]	– –	. . [0.43]	1,498,854 [105,230]	18,821 [1,302]	Mining from No. 2 block has started.
Placid Oil Company, Bull River mine, Cranbrook	750 –	2.03 –	– –	– –	0.78 –	35,528 –	484 –	Production commenced Oct. 1971.
Texada Mines Ltd., Vananda	4,500 [4,500]	0.27 [0.26]	– –	– –	0.02 [0.02]	1,231,068 [1,230,153]	2,026 [1,872]	Copper concentrate produced as byproduct of iron mining and beneficiation.
Utah Mines Ltd., Island Copper mine, Coal Harbour, V.I.	33,000 –	0.51 –	– –	– –	. . –	1,040,608 –	4,020 –	Production started Oct. 1971.
Western Mines Limited, Buttle Lake, V.I.	750 [750]	2.00 [1.97]	6.90 [6.38]	– –	1.60 [1.36]	386,541 [386,976]	6,765 [7,158]	

Table 3 (concl'd)

Company and Location	Mill or Mine Capacity	Grade of Ore: Copper	Zinc	Nickel	Silver	Produced	Contained Copper Produced	Remarks
	(tons ore/day)	(%)	(%)	(%)	(oz/ton)	(tons)	(tons)	
Yukon Territory								
Whitehorse Copper Mines Ltd. (formerly New Imperial Mines Ltd.), Whitehorse	2,000 [2,500]	1.02 [1.04]	– –	– –	. . . .	337,758 [852,461]	2,618 [8,042]	Operations suspended June, 1971 pending completion of underground development of Middle Chief and Little Chief orebodies.
Northwest Territories								
Echo Bay Mines Ltd., Port Radium	100 [100]	0.90 [1.17]	– –	– –	68.90 [70.00]	36,820 [36,925]	332 [390]	Continuing development of bottom levels.
Terra Mining and Exploration Limited, Sawmill Bay, Great Slave Lake	300 [200]	0.87 [0.90]	– –	– –	33.70 [13.70]	48,715 [32,867]	392 [275]	Continuing exploration.

–Nil; . . Not available; [d] Deliveries.



Producers

(numbers refer to numbers on map)

1. American Smelting and Refining Company (Buchans)
2. British Newfoundland Exploration Limited (Whalesback and Little Deer mines)
   Consolidated Rambler Mines Limited
3. First Maritime Mining Corporation Limited (Gulbridge mine)
5. Dresser Minerals, Division of Dresser Industries, Inc. (Walton)
6. Anaconda American Brass Limited (Caribou mine)
   Brunswick Mining and Smelting Corporation Limited (No. 6 and No. 12 mines)
   Heath Steele Mines Limited (Newcastle)
   Nigadoo River Mines Limited (Robertville)
7. Gaspé Copper Mines, Limited (Murdochville)
8. Madeleine Mines Ltd. (Gaspé Provincial Park)
10. Sullivan Mining Group Ltd. (Cupra, D'Estrie, Weedon mines)
11. Campbell Chibougamau Mines Ltd. (Original, Kokko Creek, Merrill Island, Cedar Bay, Henderson mines)
    Icon Sullivan Joint Venture (Chibougamau)
    Patino Mines (Quebec) Limited, Copper Rand Mines Division (Copper Rand, Portage, Jaculet, Copper Cliff mines)
12. Falconbridge Copper Limited, Opemiska Division
13. Renzy Mines Limited (Hainault Township)
14. Louvem Mining Company Inc. (Louvincourt)
    Manitou-Barvue Mines Limited (Val-d'Or)
15. Bell Allard Mines Limited (Matagami)
    Joutel Copper Mines Limited (Joutel)
    Mattagami Lake Mines Limited (Matagami)
    New Hosco Mines Limited (Matagami)
    Orchan Mines Limited (Matagami)
    Rio Algom Mines Limited (Mines de Poirer mine)
16. Normetal Mines Limited (Normetal)
17. Delbridge Mines Limited (Noranda)
    Falconbridge Copper Limited, Lake Dufault Division
    Noranda Mines Limited (Horne mine)
    Quemont Mines Limited (Noranda)
19. Copperfields Mining Corporation Limited (Timagami mine)

20. Upper Beaver Mines Limited (Dobie)
21. Falconbridge Nickel Mines Limited (Falconbridge, East, Strathcona, Hardy, Fecunis Lake, Onaping, North, Longvac South mines)
    The International Nickel Company of Canada, Limited (Frood-Stobie, Creighton, Garson, Levack, Copper Cliff North, Crean Hill, Totten, Murray, MacLennan, Copper Cliff South, Coleman, Clarabelle, and Crean Hill mines)
22. Canadian Jamieson Mines Limited (Timmins)
    Ecstall Mining Limited (Kidd Creek mine)
    Jameland Mines Limited (Timmins)
    Kam-Kotia Mines Limited (Timmins)
    McIntyre Porcupine Mines Limited (Schumacher)
24. Rio Algom Mines Limited (Pronto Division)
25. Tribag Mining Co., Limited (Batchawana Bay)
    North Canadian Enterprises Limited (Coppercorp mine)
26. Noranda Mines Limited (Geco Division)
    Willroy Mines Limited (Willecho and Willroy mines)
29. Selco Mining Corporation (Uchi Lake)
30. Consolidated Canadian Faraday Limited (Werner Lake Division)
31. Dumbarton Mines Limited (Bird River)
32. Falconbridge Nickel Mines Limited (Manibridge mine)
    The International Nickel Company of Canada, Limited (Birchtree, Pipe, Soab and Thompson mines)
33. Hudson Bay Mining and Smelting Co., Limited (Anderson, Chisel, Dickstone, Flexar, Flin Flon, Osborne, Schist, and Stall mines)
34. Sherritt Gordon Mines, Limited (Lynn Lake and Fox Lake mines)
35. Rio Algom Mines Limited (Anglo-Rouyn mine)
36. Placid Oil Company (Bull River deposit)
37. The Granby Mining Company Limited, Phoenix Copper Division
38. Brenda Mines Ltd. (Peachland)
39. Bethlehem Copper Corporation Ltd. (Highland Valley)
    Craigmont Mines Limited (Merritt)
40. Giant Mascot Mines Limited (Hope)
41. Anaconda Britannia Mines Ltd. (Britannia Beach)
42. Texada Mines Ltd. (Vananda)
43. Western Mines Limited (Buttle Lake, V.I.)
44. Cominco Ltd. (Coast Copper Mines, V.I.)
    Utah Mines Ltd. (Island Copper mine)
46. The Granby Mining Company Limited (Granisle mine)
47. Falconbridge Nickel Mines Limited (Wesfrob mine, Q.C.I.)
48. Granduc Operating Company (Stewart)
50. Churchill Copper Corporation Ltd. (Magnum Creek)
52. Whitehorse Copper Mines Ltd. (Whitehorse)
54. Terra Mining and Exploration Limited (Sawmill Bay)
55. Echo Bay Mines Ltd. (Port Radium)

Prospective producers

6. Heath Steele Mines Limited (Little River mine)
15. Orchan Mines Limited (Garon Lake mine)
21. Falconbridge Nickel Mines Limited (Lockerby and Thayer Lindsley mines)
    The International Nickel Company of Canada, Limited (Levack West mine)
27. The International Nickel Company of Canada, Limited (Shebandowan)
28. Mattabi Mines Limited (Sturgeon Lake)
33. Hudson Bay Mining and Smelting Co., Limited (Ghost Lake and White Lake mines)
34. Sherritt Gordon Mines, Limited (Ruttan Lake)
39. Lornex Mining Corporation Ltd. (Highland Valley)
    Alwin Mining Company Ltd. (Highland Valley)
40. Similkameen Mining Company Limited (Ingerbelle and Similkameen deposits)
45. Gibralter Mines Ltd. (McLeese Lake)
46. Noranda Mines Limited (Bell Copper deposit)
53. Hudson-Yukon Mining Co., Limited (Wellgreen mine)
56. Jordan River Mines Ltd. (Sunro mine)

Exploration projects

4. Union Minière Explorations and Mining Corporation Limited (Thierry deposit)
9. New Quebec Raglan Mines Limited (Wakeham Bay)
21. The International Nickel Company of Canada, Limited (Cryderman, Victoria and Whistle mines)
    Falconbridge Nickel Mines Limited (Fraser and Onex mines)
28. Sturgeon Lake Mines Limited (Sturgeon Lake)
33. Hudson Bay Mining and Smelting Co., Limited (Centennial, Rail Lake, Reed Lake and Wim mines)
    Stall Lake Mines Limited (Snow Lake)
39. Highmont Mining Corp. Ltd. (Highland Valley)
    Valley Copper Mines Limited (Highland Valley)
    Afton Mines Ltd. (Kamloops)
    Bethlehem Copper Corporation Ltd. (J-A and Maggie zones)
40. Giant Mascot Mines Limited (Canam mine)
43. Catface Copper Mines Limited (Tofino)
49. Davis-Keays Mining Co. Ltd. (Fort Nelson)
51. Liard Copper Mines Ltd. (Telegraph Creek)
    Stikine Copper Limited (Galore Creek)

Smelters

7. Gaspé Copper Mines, Limited (Murdochville)
17. Noranda Mines Limited (Noranda)
21. The International Nickel Company of Canada, Limited (Coniston)
    The International Nickel Company of Canada, Limited (Copper Cliff)
    Falconbridge Nickel Mines Limited (Falconbridge)
33. Hudson Bay Mining and Smelting Co., Limited (Flin Flon)

Refineries

18. Canadian Copper Refiners Limited
21. The International Nickel Company of Canada, Limited (Copper Cliff)

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				
Heath Steele Mines Limited, Newcastle, Little River mine	– Cu (. .) Zn (. .)	1975	Murdochville	Mill capacity to be increased from 3,000 to 4,000 tpd.
Quebec				
Orchan Mines Limited, Matagami				
Garon Lake mine	– Cu (1.73) Zn (3.42)	late 1972	Noranda	
Radiore mine	– Cu (2.61) Zn (1.35)	. .	Noranda	
Ontario				
Falconbridge Nickel Mines Limited, Falconbridge				
Lockerby mine	. .	. .	Falconbridge	
Thayer Lindsley mine	– Cu (. .) Ni (. .)	. .	Falconbridge	
The International Nickel Company of Canada, Limited, Copper Cliff				
Levack West mine	–	1975	Copper Cliff	
Shebandowan mine	2,500 Cu (. .) Ni (. .)	1972	Copper Cliff	
Mattabi Mines Limited, Sturgeon Lake	3,000 Cu (0.91) Pb (0.84) Zn (7.60)	1972	Noranda	
Manitoba				
Hudson Bay Mining and Smelting Co., Limited, Flin Flon and Snow Lake				
Ghost Lake mine	– Cu (1.42) Zn (11.60)	1972	Flin Flon	
White Lake mine	– Cu (2.22) Zn (6.20)	1972	Flin Flon	Will be mined at 450 tpd.
Sherritt Gordon Mines, Limited, Ruttan Lake	10,000 Cu (1.47) Zn (1.61)	1973	Noranda	Open-pit mining for first six years, followed by underground mining.

Table 4 (concl'd)

Company and Location	Mill Capacity[2] and Ore Grade	Year Production Expected	Destination of Copper Concentrates	Remarks
	(%)			
British Columbia				
Alwin Mining Company Ltd., Highland Valley	500 Cu (2.33)	1972	W. Germany	
Gibralter Mines Ltd., McLeese Lake, Cariboo District	30,000 Cu (0.37) MoS_2 (0.016)	1972	Japan	
Jordan River Mines Ltd., Jordan River, V.I. Sunro mine	1,500 Cu (1.21)	1972	W. Germany	
Lornex Mining Corporation Ltd., Highland Valley	38,000 Cu (0.44) MoS_2 (0.014)	1972	Japan	
Noranda Mines Limited, Babine Lake Bell deposit	10,000 Cu (0.50)	1972	Noranda or Murdochville	
Similkameen Mining Company Limited, Princeton, Ingerbelle and Similkameen deposits	15,000 Cu (0.53)	1972	Japan	
Yukon Territory				
Hudson-Yukon Mining Co., Limited, Kluane Lake Wellgreen mine	600 Cu (1.42) Ni (2.04)	1972	Japan	Mine closing in 1973 because mining will not be economic.

[1]Only mines with announced production plans. [2]Mill capacity in tons of ore a day.
– Nil; . . Not available.

Consumption. Eight fabricating and semifabricating companies use 90 to 95 per cent of the refined copper sold in Canada. Four of these companies are rod rollers that make wire rod for their own and other wire drawing operations. The other four companies own copper and brass mills that make sheet, strip, bars, pipe, tubes, etc.

Of the copper reported to have been consumed by the fabricating and semifabricating companies (Table 8), about half is used for wire and cable, a third for copper mill products, and a sixth for brass mill products. Less than one per cent is used for miscellaneous items that include chemicals.

Federal Government action. The Federal Government did not intervene in the distribution of copper during 1971, as it had earlier through price and supply controls. Copper remains on the exports control list but permits are freely given. The only control remaining is that requiring any mine shipping copper concentrates to a domestic smelter to continue doing so. An interdepartmental committee of the Federal Government continued to investigate, in consultation will all segments of the industry, alternative programs that could be followed to meet normal domestic requirements, should higher offshore prices again threaten to drain copper from Canada.

DISPOSITION OF CANADIAN MINE PRODUCTION OF COPPER, 1971

MINERAL RESOURCES BRANCH
DEPARTMENT OF ENERGY, MINES AND RESOURCES

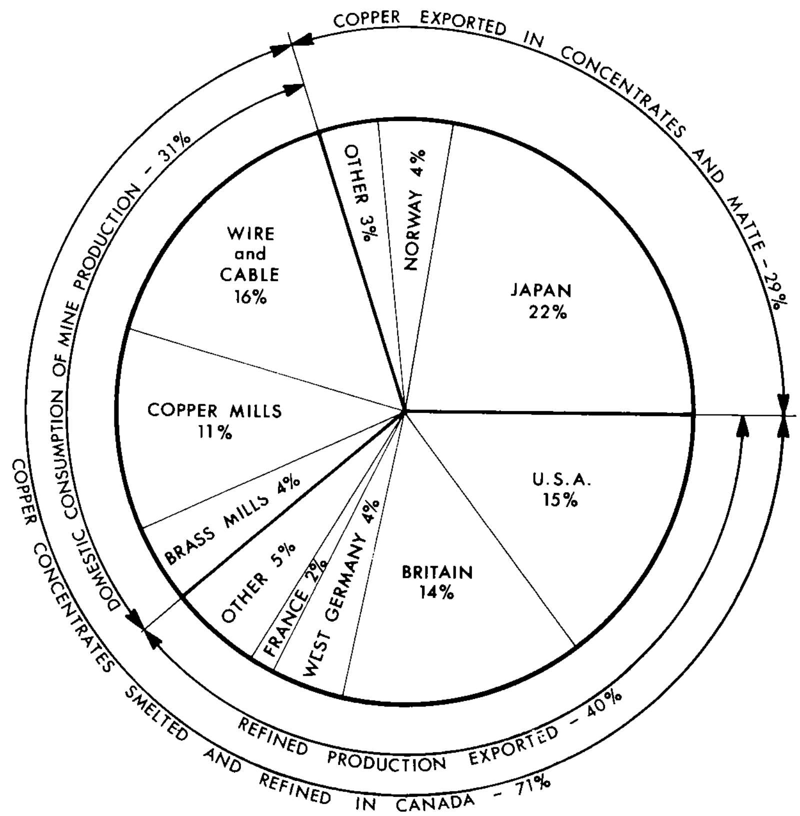


Table 5. Copper exploration projects

Company and Location	Indicated Ore Tonnage	Grade of Ore	Remarks
	(tons)	(%)	
Quebec			
New Quebec Raglan Mines Limited, Wakeham Bay	16,050,000	Cu (0.71) Ni (2.58)	Property held in abeyance.
Ontario			
Falconbridge Nickel Mines Limited, Falconbridge			
Fraser mine	. .	Cu (. .)	Development work deferred at both mines.
Onex mine	. .	Ni (. .)	
The International Nickel Company of Canada, Limited, Copper Cliff,			
Cryderman mine	. .	Cu (. .)	
Victoria mine	. .	Ni (. .)	
Whistle mine	. .		

Table 5 (concl'd)

Company and Location	Indicated Ore Tonnage	Grade of Ore	Remarks
	(tons)	(%)	
Sturgeon Lake Mines Limited, Sturgeon Lake	1,928,000	Cu (3.00) Zn (7.85) Ag (4.54 oz/ton)	Detailed engineering studies under way.
Union Minière Explorations and Mining Corporation Limited, Pickle Crow Thierry deposit	10,000,000	Cu (1.60) Ni (0.29)	Shaft sinking for underground exploration under way.
Manitoba			
Hudson Bay Mining and Smelting Co., Limited, Flin Flon			
Centennial mine	1,400,000	Cu (2.06) Zn (2.60)	
Rail Lake mine	325,000	Cu (3.00)	
Reed Lake mine,	1,142,000	Cu (2.18)	
Wim mine	1,000,000	Cu (3.00)	
Stall Lake Mines Limited, Snow Lake	672,000	Cu (5.38) Zn (2.28)	
British Columbia			
Afton Mines Ltd., Kamloops	40,000,000	Cu (0.65)	
Bethlehem Copper Corporation Ltd., Highland Valley,			
J-A zone	300,000,000	Cu (0.45)	
Maggie zone	200,000,000	Cu (0.40 equiv.)	
Catface Copper Mines Limited, Tofino, V.I.	. .	Cu (. .)	Diamond drilling program was conducted from exploration adit.
Davis-Keays Mining Co. Ltd., Fort Nelson	1,400,000	Cu (3.40)	Surface drilling program under way.
Giant Mascot Mines Limited, Hope, Giant Copper (Canam) mine	2,600,000	Cu (1.28)	
Highmont Mining Corp. Ltd., Highland Valley	150,000,000	Cu (0.285) MoS_2 (0.051)	Awaiting financing to bring property into production at 25,000 tpd.
Liard Copper Mines Ltd., Telegraph Creek	294,000,000	Cu (0.40) MoS_2 (0.036)	
Stikine Copper Limited, Stikine River area	100,000,000	Cu (1.00)	New exploration program under way.
Valley Copper Mines Limited, Highland Valley	600,000 per vertical foot	Cu (0.46)	Financing and marketing being investigated.

. . Not available.

Table 6. Canadian copper and copper-nickel smelters, 1970

Operator and Location	Product	Rated Annual Capacity	Remarks	Ore and Concentrate Treated	Blister or Anode Copper Produced
		(short tons)		(short tons)	(short tons)
Falconbridge Nickel Mines Limited, Falconbridge, Ont.	Copper-nickel matte	650,000[1]	Copper-nickel ore and sintered concentrate smelted in blast furnaces; converted to produce matte for shipment to company's electrolytic refinery in Norway	. .	. .
Gaspé Copper Mines, Limited, Murdochville, Que.	Copper anodes, metallic bismuth	370,000[1]	One reverberatory furnace for green or wet-change concentrates, 2 Pierce-Smith converters, 1 anode furnace, 1 Walker casting wheel. Also smelts custom concentrates.	377,800 (of which 156,000 were custom concentrates)	73,800
Hudson Bay Mining and Smelting Co., Limited, Flin Flon, Man.	Blister-copper cakes	575,000[1]	Roasting furnaces, 1 reverberatory furnace, 3 converters, for treating copper flotation concentrates and zinc-plant residues in conjunction with slag-fuming furnaces. Treats some concentrates on toll.	234,100 (of which 19,100 were custom concentrates)	27,424
The International Nickel Company of Canada, Limited, Coniston, Ont.	Copper-nickel Bessemer matte	800,000[1]	Sintering; blast furnace smelting of nickel-copper ore and concentrate; converters for production of copper-nickel Bessemer matte	. .	. .
Copper Cliff, Ont.	Blister copper, nickel sulphide and nickel sinter for company's refineries; nickel oxide sinter for market	4,000,000[1]	Oxygen flash-smelting of copper sulphide concentrate; converters for production of blister copper. Blast furnaces, 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 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 to blister copper.	. .	. .

Table 6 (concl'd)

Operator and Location	Product	Rated Annual Capacity	Remarks	Ore and Concentrate Treated	Blister or Anode Copper Produced
		(short tons)		(short tons)	(short tons)
Noranda Mines Limited, Noranda Que.	Copper anodes	1,700,000[2]	Roasting furnaces, 2 hot-charge reverberatory furnaces, 1 green-charge reverberatory furnace, 5 converters. Also smelts custom material.	1,549,600 (of which 825,500 were custom material)	233,040

Source: Company reports.
. . Not available. [1]Ores and concentrates. [2]Ores, concentrates and scrap.

Table 7. Copper refineries in Canada, 1970

Refinery	Products
Canadian Copper Refiners Limited, Montreal East, Quebec (subsidiary of Noranda Mines Limited)	Rated annual capacity 350,000 tons. Output 342,000 tons. Refines anode copper from Noranda and Gaspé smelters, blister copper from Flin Flon smelter, and purchased scrap. Copper sulphate recovered by vacuum evaporation. Precious metals, selenium and tellurium recovered from anode slimes.
	CCR brand electrolytic copper wire bars, ingot bars, ingots cathodes, cakes and billets.
The International Nickel Company of Canada, Limited, Copper Refining Division Copper Cliff, Ont.	Rated annual capacity 198,000 tons. Refining of blister copper from Copper Cliff smelter. Also custom refining. Precious metals, selenium and tellurium are recovered from anode slimes.
	ORC brand electrolytic copper, cathodes, wire bars, cakes, billets, ingots and ingot bars.

Source: Company reports.

Table 8. Canada, consumption of primary copper in manufacture of semi-fabricated products, 1969-71

	1969	1970	1971
	(short tons)		
Copper mill products – sheet, strip, bars, rolls, pipe, tube, etc.	63,100	66,833	61,131
Brass mill products – plate, sheet, strip, rods, bars, rolls, pipe, tubes, etc.	45,497	28,483	19,951
Wire and rod mill products	92,863	97,806	99,682
Miscellaneous	1,420	1,745	1,636
Total	202,880	194,867	182,400

Source: Statistics Canada.

World supply and demand

Mine production. World mine production of copper for 1970 and 1971 is shown in Table 9.

United States' mine production of copper was 186,000 tons lower in 1971 than in 1970 because of a strike in the industry that is estimated to have caused a 250,000-ton loss of output. Chilean production, although some 24,000 tons higher than in 1970, continued to be hampered by a shortage of skilled technical personnel. Production in Zambia in 1971 was 36,000 tons lower than in the previous year as a result of complications arising from the Mufulira disaster of 1970. Strikes caused some disruption of production in Peru. World production rose by 30,000 tons during 1971, a mere 0.4 per cent. It is obvious that if the strikes had not occurred in the United States, world production would have risen by 4.0 per cent and copper prices would probably not have been maintained as well as they were.

Table 12 shows quite clearly the relative importance of the various segments into which the copper industry is divided. The United States is a small net importer of copper; the U.S.S.R. is an exporter, but the communist bloc as a whole is a net importer. Japan and Europe are the large importing areas that are supplied by exports from the four CIPEC nations (Chile, Peru, Zaire and Zambia), Canada, and the increasingly important group listed as other noncommunist countries. In general, it is nations with an undeveloped or underveloped industrial capability that have surplus copper for sale, whereas it is the highly industrialized nations that must purchase copper for their needs. There is much disagreement as to the level of processing at which this trade in copper should take place, with the underveloped nations wishing to export at progressively higher levels of processing while the developed nations wish to import raw materials and do the processing themselves. This disagreement is far from being resolved and will undoubtedly be a core issue in any future international trade discussions.

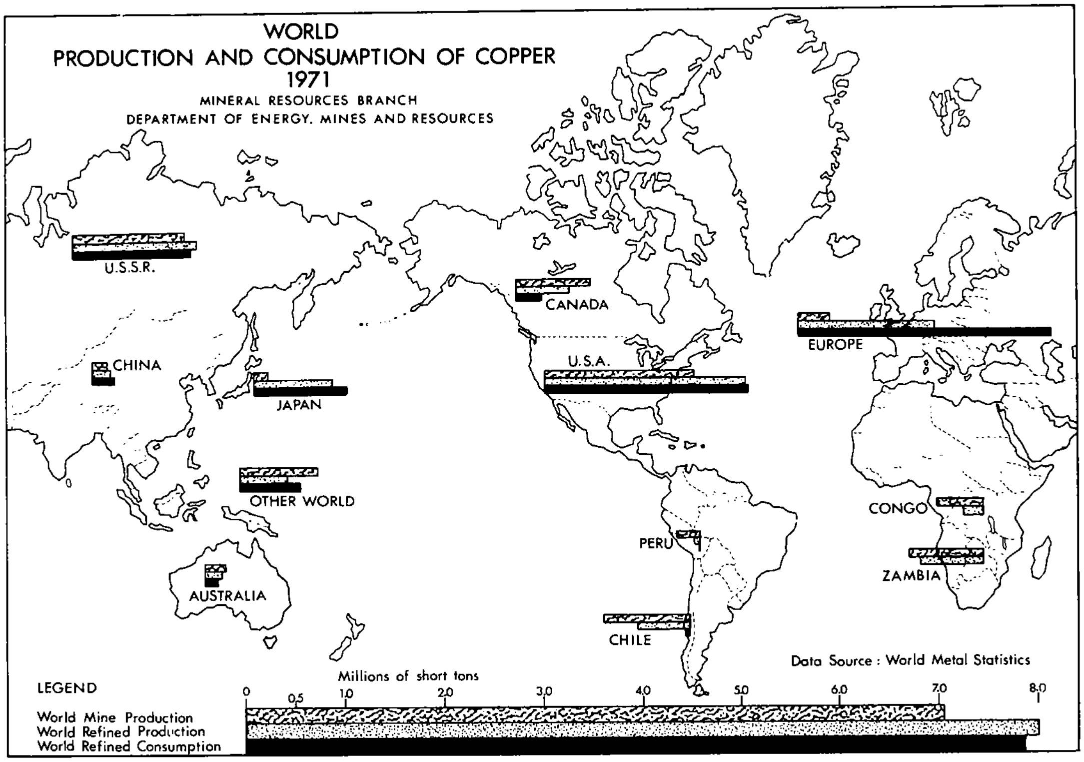
Table 9. World mine production of copper, 1970-71

	1970	1971
	(000 short tons)	
United States	1,719.6	1,533.1
U.S.S.R.	1,019.6[e]	1,058.2[e]
Chile	755.7	779.9
Zambia	754.1	718.0
Canada	672.7	714.5
Zaire	426.7	449.7
Peru	233.8	224.1
Philippines	176.7	217.6
Australia	173.9	187.3
Republic of South Africa	159.0	162.8
Japan	131.6	132.8
China (People's Republic)	132.2[e]	132.2[e]
Yugoslavia	108.0	118.3
Poland	71.7	79.3
Mexico	67.2	70.1
Other communist countries	84.9[e]	89.0[e]
Other noncommunist countries	314.3	364.2
Total	7,001.7	7,031.1

Source: World Metal Statistics, June 1972.
[e]Estimated.

World mine production of copper is expected to expand rapidly in the next few years as major mining developments in many parts of the world come on stream. It seems incongruous that this should be happening during a time of surplus supply. However, these expansions were initiated three of four years ago when copper was in short supply and because of the capital-intensive nature of the industry it is impractical to delay completion of the ventures pending better market conditions.

Expansion of the world copper mining industry will continue, but at a reduced scale. New production in Chile, Peru and Iran will likely take much longer to materialize than anticipated. The huge operation on Bougainville is reported to be on schedule as are most Canadian developments. Other new mines are scheduled to be opened in Zambia, Zaire, West Irian, Spain, Mauritania, Australia, India and Turkey in the next few years. It has been reported that the U.S.S.R. has approached United States interests about the possibility of developing the Udokan sedimentary



copper deposit in Siberia, northeast of Lake Baikal. Reports indicate that Udokan is the world's largest known copper deposit although tonnage and grade estimates have not been revealed.

Barring unforeseen developments in other countries, Canada's position in world mine production is likely to be improved from fifth to fourth, or even third, in the near future.

Metal production. The world production of refined copper for 1970 and 1971 is shown in Table 10.

Lately the press has been discussing the amount of copper smelting capacity that exists or is under construction in the world. This discussion has been prompted by the rapid increase in mine production, the fact that some smelters in the United States and Japan have been forced to reduce smelting rates to meet gaseous emission standards, and a realization that few new smelters are being built. This lack of new smelter construction is subject to much speculation, but there could be a hesitation on the part of smelter operators to invest large sums of money in plants that might be rendered ecologically or economically obsolete before they are amortized, a distinct possibility since a new generation of reduction techniques is in the development stage.

Japan is nearing completion of a smelter modernization program that will see former blast furnaces replaced with either modern flash furnaces or reverberatory furnaces, all equipped with effective sulphur recovery plants. When these new furnaces are all operating in 1973, capacity will be above previous levels and further expansion will be readily possible. This modernization program in Japan has been necessary because of government actions to correct the serious air pollution problem that exists over much of southern Japan. Some smelters have been forced to reduce operations, because of emission standards and slow sales for their products. One smelting company declared *force majeure* on 20 per cent of the concentrates for which it had contracted. In addition, to prevent blowing dust, the smelters have been required to erect concentrate storage buildings.

Research into better methods of reducing copper ores and concentrates to metal is continuing on two fronts, hydrometallurgy and continuous smelting.

Table 10. World production of refined copper, 1970-71

	1970	1971
	(000 short tons)	
United States	2,241.9	1,966.9
U.S.S.R.	1,185.0[e]	1,217.0[e]
Japan	777.5	786.3
Zambia	640.1	589.0
Canada	543.1	526.4
Chile	508.5	515.7
Germany (Federal Republic)	447.3	441.0
Belgium	372.1	344.8
Zaire	209.0	220.5
Britain	227.3	206.7
Australia	160.4	172.3
China	143.3[e]	145.5[e]
Yugoslavia	98.4	102.1
Poland	79.6	92.6
Republic of South Africa	83.0	87.1
Spain	91.3	80.7
Mexico	59.2	65.8
Sweden	56.4	54.7
Other communist countries	131.7[e]	140.2[e]
Other noncommunist countries	252.3	239.8
Total	8,307.4	7,995.1

Source: World Metal Statistics, June 1972.
[e]Estimated.

Most hydrometallurgical research programs are still at the laboratory or pilot plant stage and large-scale commercial adaptation of any design is a few years away. Continuous smelting, however, is further along. As mentioned previously, Noranda Mines is constructing a commercial unit at Noranda. In addition, the Mitsubishi interests are operating a pilot plant of their own design at the Onahama smelter in Japan, and the Conzinc-Rio Tinto group has financed a pilot plant operation of the Worcra process. It is anticipated that two or three years of testing will be required for the Mitsubishi process, while the Worcra research personnel have completed a number of tests and are trying to arrange financing to construct a semicommercial plant. Continuous smelting, with lower construction and operating costs, shows promise of replacing conventional smelting in the medium term.

The Intergovernmental Council of Copper Exporting Countries (CIPEC), composed of representatives from Chile, Peru, Zaire (formerly Republic of Congo) and Zambia, held its second Conference of Ministers in Kinshasa, Zaire, from May 27 to 29, 1971. Observers attended from the Philippines, Mauritania, Iran and Canada but were invited only to the opening and closing sessions and had no part in the proceedings. CIPEC was unable to announce any meaningful measures to support the price of copper although this was acknowledged to have been a main topic of discussion. Other topics discussed included an improved structure for CIPEC and expanded membership.

Consumption. The consumption of refined copper in the world for 1970 and 1971 is shown in Table 11.

The only trend suggested by these statistics is that the communist countries are estimated to have used more copper in 1971 than in 1970 while the noncommunist countries generally used less. The economic slump that continued throughout 1971 in the United States, Europe and Japan accounted for the slow demand for copper in these areas, the predominant consuming areas in the noncommunist world. Little improvement can be expected until the economies in these countries resume their upward trend.

Uses

Copper's properties of malleability, ductility, conductivity, corrosion resistance, alloying qualities and pleasing appearance make its use universal in the electrical, construction, plumbing and automotive industries. Approximately half of all copper consumed is

Table 11. World consumption of refined copper, 1970-71

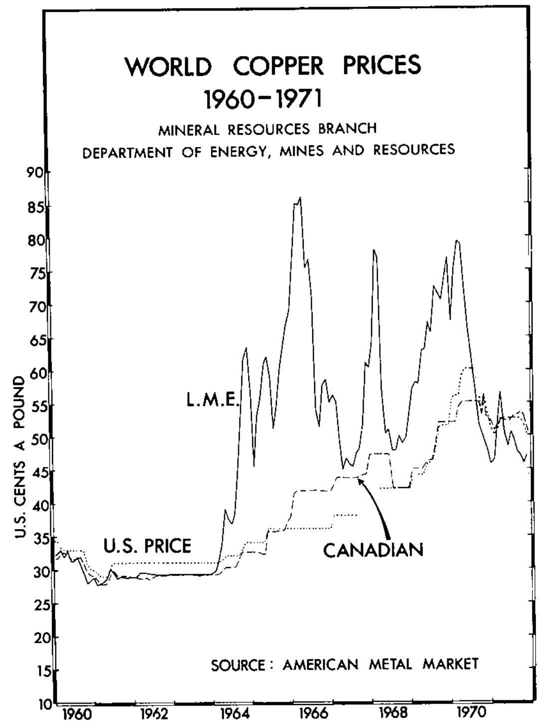
	1970	1971
	(000 short tons)	
United States	2,042.0	2,014.0
U.S.S.R.	1,102.3[e]	1,137.6[e]
Japan	898.4	910.2
Germany (Federal Republic)	768.9	694.9
Britain	605.9	561.8
France	364.5	378.7
Italy	302.0	303.2
China (People's Republic)	220.5[e]	231.5[e]
Canada	237.8	221.1
Belgium	120.7	125.0
Australia	122.2	115.6
Spain	119.3	114.0
Germany (Democratic Republic)	99.2	99.2
Sweden	95.8	99.2
Yugoslavia	86.2	74.8
Other communist countries	209.4[e]	231.5[e]
Other noncommunist countries	563.6	584.0
Total	7,958.7	7,896.3

Source: World Metal Statistics, June 1972.
[e]Estimated.

Table 12. World copper production and consumption, 1971

	Mine Production	Refined Production	Refined Consumption
	(000 short tons)		
United States	1,533.1	1,966.9	2,014.0
U.S.S.R.	1,058.2^e	1,217.0^e	1,137.6^e
Japan	132.8	786.3	910.2
CIPEC	2,171.7	1,360.5	33.8
Europe	278.0	1,366.3	2,564.5
Canada	714.5	526.4	221.1
Other communist countries	300.5^e	378.3^e	562.2^e
Other noncommunist countries	842.3	393.4	452.4
Total	7,031.1	7,995.1	7,896.3

Source: World Metal Statistics, June 1972.
^{e}Estimated.



for electrical applications, including power transmission, electronics and electrical equipment, and transportation. Generation and utilization of electrical energy requires very large quantities of copper for heat exchangers, bus bars, magnet wire, and windings in motors, generators and transformers.

The noncorrosive qualities of copper and its alloys account for many uses in construction, for plumbing goods, builders' hardware, and roofing products. Copper alloys are used in bearings, fastenings and fitting for marine hardware. In the automotive industry, copper is used in radiators, wires, bearings, bushings, switches and oil lines.

The principal copper and brass fabricators in Canada are: in British Columbia – Norco Industries Ltd. (formerly Noranda Metal Industries Ltd.), Vancouver; in Ontario – Anaconda American Brass Limited, Toronto; Phillips Cables Limited, Brockville; Ratcliffs (Canada) Limited, Richmond Hill; Wolverine Tube Division of UOP Company Limited (formerly Calumet & Hecla (Canadian) Limited), London; in Quebec – The Noranda Copper Mills Limited, Montreal East; Pirelli Canada Ltd., St-Jean; Northern Electric Company, Limited, Montreal; and Canada Wire and Cable Company, Limited, Montreal.

Prices

The London Metal Exchange (LME) cash copper price was equivalent to 47.02 cents U.S. a pound at the start of 1971. It rose to a high of 58.29 cents on April 1 on hedge buying because of an expected strike in the United States industry coupled with an announcement of a declaration of *force majeure* on shipments from Chile's El Teniente mine. The LME price declined to 46.26 cents early in June, had a short rise to 54.81 cents in July after the anticipated strike in the United States was under way and showed little movement for the remainder of the year, finishing in the 46- to 47-cent range.

The United States producers' price opened 1971 at 53 cents U.S. a pound, was lowered to 50 3/8 cents in mid-January, and rose to 52 3/4 – 53 late in March. This price held until late November when it was adjusted to 50 1/4 – 50 1/2 where it ended the year.

The Canadian producers' price was quoted at 53 3/4 – 54 cents (Canadian) a pound at the start of 1971. It was lowered to 51 cents on January 13, raised to 53 – 53 1/8 on March 30, and raised again to 53 3/4 on June 16. This price held until late November when a price of 50 3/8 was announced and remained in effect to the end of the year. These prices were quoted by Noranda Mines Limited, Hudson Bay Mining and Smelting Co., Limited, and Texas Gulf Sulphur Company. Inco was quoting the Canadian equivalent of the United States producers' price as its domestic price.

Outlook

The outlook for the Canadian copper industry in 1972 is for increasing mine production with refinery output remaining fairly steady. Consumption should remain within limits established in previous years. Installed mine capacity by the end of 1972, if all projects are completed as scheduled, will be sufficient to produce 837,000 tons of copper annually. Production could be affected by labour troubles in the second half of the year.

Internationally, increased mine production will not be matched by increased smelter and refinery capacities. These facilities should be adequate during 1972 but there is danger of a shortage of copper smelter capacity in future years. This situation could provide the impetus needed to assure the establishment of a smelter-refinery complex in western Canada in the near future. World consumption of refined copper should exceed that for 1971 but the growth rate is expected to be lower than that which existed during the last decade.

Tariffs

Canada

Item No.		British Preferential	Most Favoured Nation	General
			(%)	
32900-1	Copper in ores and concentrates	free	free	free
34800-1	Copper in pigs, blocks, or ingots, cathodes, plates, copper matte, and blister and copper scrap, per lb	free	free	1½¢
				(%)
33503-1	Copper oxides	free	15	25
34820-1	Copper in bars or in rods, for manufacture of trolley, telegraph, telephone wires, electric wires and cables	free	5	10
34835-1	Electrolytic copper powder (expires Jan. 31, 1972)	free	free	10
34845-1	Electrolytic copper wire bars, per lb (expires Jan. 31, 1972)	free	free	1½¢
35800-1	Anodes of copper	free	free	10%

United States

Item No.		On and After January 1 1970	1971	1972
		(¢ per lb)		
602.30	Copper ores and concentrates, on Cu content (under suspension to June 30, 1972)			
612.06	Unwrought copper, on Cu content (under suspension to June 30, 1972)	1.1	1	0.8
612.10	Copper waste and scrap, on 99.6% of Cu content (under suspension to June 30, 1972)			

Sources: The Custom Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa. Tariff Schedules of the United States, Annotated (1972), T.C. Publication 452.

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 there has been a rapid growth in world fluorspar consumption because of increasing demands in the steel, aluminum and chemical industries. In 1971 world consumption reached an estimated 4.8 million short tons and, based on forecast demands by the major consuming industries, consumption is expected to reach some 6.7 million tons by 1975. Contributing to this increase will be a 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. Increasing world consumption of aluminum coupled with ever-widening usage of fluorocarbons and other fluorine chemicals will continue to stimulate world demand for acid-grade material.

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.

During 1970 Newfoundland Fluorspar Limited, a wholly owned subsidiary of the Aluminum Company of Canada, Limited (Alcan) was merged into its parent company and fluorspar operations are now carried out by the Newfoundland Fluorspar Works of Aluminum Company of Canada, Limited. This company produces fluorspar from two mines, the Director and the Tarefare both located near the village of St. Lawrence in Newfoundland. The Director mine has been in operation for 29 years. In August 1968 the Tarefare was brought into production and produces about 25,000 tons a year of fluorspar concentrate, all of which is shipped together with virtually all the production from the Director mine to Alcan's aluminum smelter at Arvida. The concentrate is upgraded and then converted to artificial cryolite, an essential cell ingredient for the reduction of alumina to aluminum. Small tonnages are sold to Newfoundland Steel (1968) Company Limited for steel slagging. A third deposit, the Blue Beach vein, is currently being developed and mill capacity has been increased to 1,200 tons per day. In 1970 shipments totalled 137,000 tons valued at $4.6 million. A five-month strike at Alcan's Newfoundland Fluorspar Works interrupted operations in 1971 and shipments are estimated at about 80,000 tons valued at $2.6 million.

Allied Chemical Canada, Ltd. imports acid-grade fluorspar for the production of hydrofluoric acid at the company's plant located at Valleyfield, Quebec. Some of the acid is utilized in the manufacture of various fluorine chemicals. Allied Chemical operates mines in Mexico and the United States in order to ensure an uninterrupted supply of fluorspar. The company established a new hydrofluoric acid plant at Amherstburg, Ontario in mid-1971.

Huntingdon Fluorspar Mines Limited with a plant at North Brook, Ontario, imports metallurgical-grade fluorspar to make 5-pound briquettes for foundry use.

Table 1. Canada, fluorspar production, trade and consumption

	1970		1971p	
	(short tons)	($)	(short tons)	($)
Production (shipments)				
Newfoundland	..	4,595,522	..	2,550,000
Imports				
Mexico	63,314	2,669,000	158,102	7,251,000
Britain	17,731	692,000	26,232	1,130,000
Italy	–	–	16,838	970,000
United States	13,637	804,000	12,651	787,000
Spain	–	–	11,270	631,000
Total	94,682	4,165,000	225,093	10,769,000
	1969		1970	
Consumption[1] (available data)				
Metallurgical flux[2]	39,571		38,352	
Glass and glass wool	2,762		1,450	
Enamels and frits	310		213	
Others[3]	158,184		172,934	
Total	200,827		212,949	

Source: Statistics Canada.
[1]As reported by consumers. Breakdown by Mineral Resources Branch.
[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.
pPreliminary; .. Not available for publication.

International Mogul Mines Limited continued assessment of barite-fluorite deposits east of Lake Ainslie, Cape Breton Island, Nova Scotia. Drilling in July 1971 expanded indicated tonnage to 2.97 million tons of ore grading 28 per cent barite and 19 per cent fluorite. Pilot plant testing initiated in 1969 continued during 1971 with the objective of producing an acid-grade concentrate at an acceptable rate of recovery. From 1940 to 1949 approximately 1,400 tons of fluorspar along with some barite was recovered from this deposit.

Prior to World War I, small tonnages of fluorspar were mined from vein-type deposits in the Madoc district of Ontario. Fluorite, a strategic material of great importance, showed a marked increase in production during the war years. After World War I production decreased substantially but was stimulated once again during World War II 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 mining uneconomic. Altogether, some 150,000 tons of fluorspar were mined in the Madoc area, production being derived from twenty-four separate properties. Most significant producing properties were along a prominent linear vein structure, the southern extension of which could still contain economically attractive reserves.

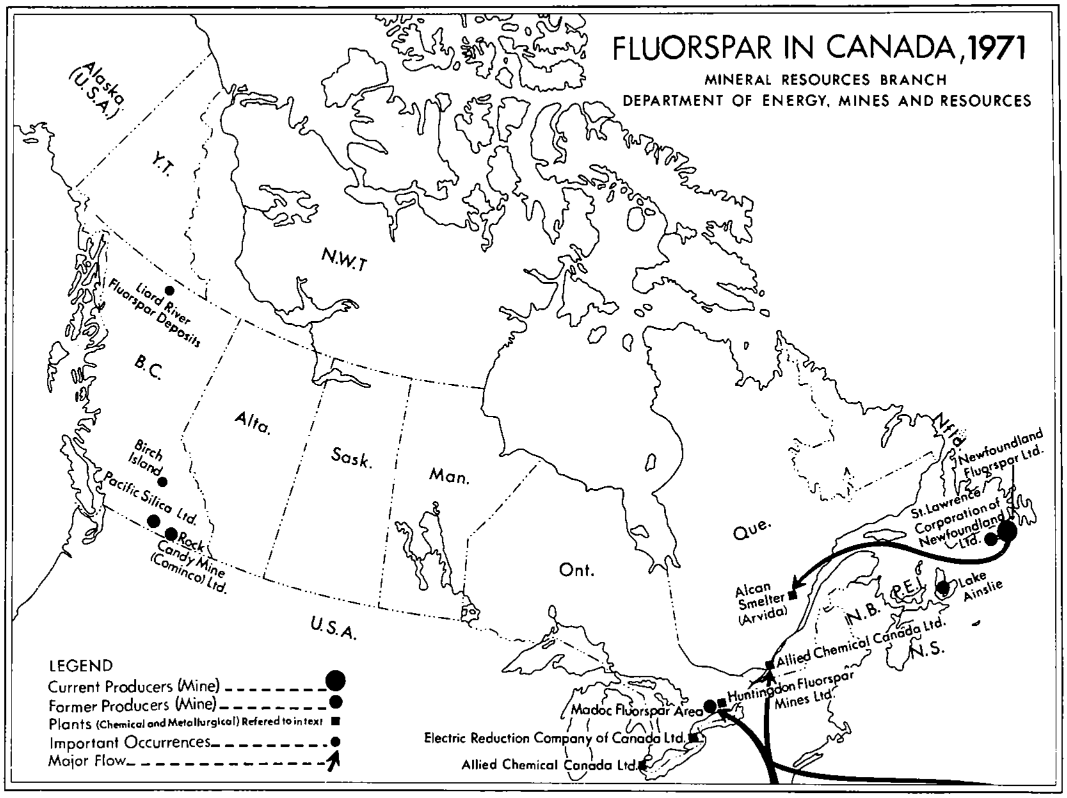
The Rock Candy mine, near Grand Forks, British Columbia was mined intermittently from 1918 to 1942 and is still controlled by Cominco Ltd. Substantial reserves probably remain.

Some fluorine is being recovered as fluorosilicic acid from the processing of phosphate rock by Electric Reduction Company of Canada, Ltd., at Port Maitland, Ontario, and by Cominco Ltd., at Trail, British Columbia.

Exploration

Increasing demand, coupled with a somewhat stagnant world reserve growth picture and higher prices for all grades of fluorspar has reactivated vigorous exploration for the mineral in areas of known occurrences both in Canada and abroad.

Fluorspar veins on Burin Peninsula are genetically related to two large stocks of alaskite. Most of this favourable area is obscured by shallow overburden and innumerable showings and float blocks containing fluorspar are known. Combustion Engineering Inc. and Allied Chemical (Canada) Ltd. have undertaken intensive exploration programs on the Burin Peninsula immediately to the north of Aluminum Company of



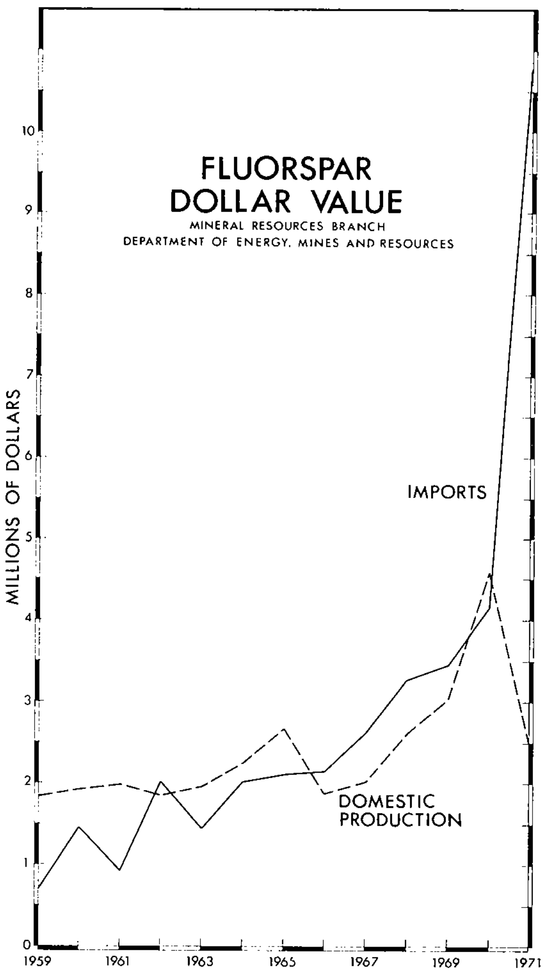
Canada, Limited's operations. The Madoc district in southern Ontario, where fluorspar was produced for many years, has recently attracted some interest. Jorex Limited in a joint venture with Conwest Exploration Company Limited staked and commenced evaluation of fluorspar occurrences in the Liard River area in northern British Columbia in mid-1971. Diamond drilling to date has indicated what may be extensive nearly flat lying fluorspar deposits amenable to open pit mining. Barite and witherite occur as accessory minerals. Assuming sufficient tonnage, development would hinge on prices adequate to meet transportation costs from this remote deposit to available markets.

Consolidated Rexspar Minerals & Chemicals Limited has a large medium-grade fluorite deposit adjacent to Canadian National Railway Company's line at Birch Island, about 60 miles north of Kamloops. Although the fluorite is fine-grained and difficult to concentrate, rising prices have stimulated renewed interest in this deposit. A program of diamond drilling, geological mapping and metallurgical testing was initiated in 1970 to augment earlier work. Geological work indicates the possibility of multiple ore-bearing structures and an assessment of these is planned. Metallurgical testing continued during 1971. Denison Mines Limited is conducting these investigations under terms of an agreement with Consolidated Rexspar.

Although not located in Canada, a Canadian company, Lost River Mining Corporation Limited, a subsidiary of Pan Central Explorations Limited, is now working on an extensive fluorspar-tin-tungsten deposit in Alaska. To date, some 32.3 million tons of ore grading 15 per cent CaF_2 have been indicated in one ore zone and an additional 6.3 million tons grading 31.0 per cent CaF_2 in another. Drilling on a third ore zone indicates the presence of a new major high-grade deposit averaging approximately 30 per cent CaF_2 over widths of 30 to 75 feet. A continuing program of diamond drilling will be carried out in 1972.

Uses, markets and trade

The most important 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.

Fluorite 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 requirements are as acid grade and, as the term implies, are used in the manufacture of hydrofluoric acid. Most of this material is beneficiated by flotation in order to achieve the high CaF_2 content required. In general 1.5-2 tons of ore must be mined to produce 1 ton of acid-grade fluorspar concentrate and the production of 1 ton of hydrofluoric acid requires 2 tons of acid-grade concentrate and almost 3 tons of sulphuric acid. Hydrofluoric acid is produced according to the reaction $CaF_2 + H_2SO_4 \rightarrow CaSO_4 + 2HF$ and has a variety of uses but by far the most important, accounting for some 80 per cent, are the aluminum and fluorocarbon industries.

Some 40 per cent 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 1 ton of primary aluminum. This is equivalent to approximately 130-140 pounds of acid-grade fluorspar concentrate. Allowing for increased cell efficiencies and fluorite recoveries from pot lines the above figure should be reduced to 125 pounds per ton of primary aluminum. Because fluorite is an essential raw material, many primary aluminum producers operate or participate in the operation of fluorspar mines in order to ensure uninterrupted and adequate supplies.

The other major use of hydrofluoric acid, accounting for some 35 per cent of consumption, is for the manufacture of fluorocarbons. Fluorocarbons, used in the manufacture of solvents, resins, plastics, films, refrigerants and aerosol propellants, are produced by

Table 2. Canada, fluorspar production, trade and consumption, 1962-71

	Production	Exports	Imports	Consumption
	(st)	(st)	(st)	(st)
1962	77,700[2]	4	67,847	123,694
1963	85,000[2]	4	66,798	142,840
1964	96,000[2]	. .	69,986	155,828
1965	1[illegible]2,000[2]	. .	69,848	167,537
1966	79,000[1]	12	75,324	166,275
1967	72,752[1] r	. .	94,244	155,349
1968	105,000[1]	. .	115,465	178,901
1969	110,000[1]	. .	104,382	200,827
1970	137,000[1]	. .	94,682	212,949
1971 p	80,000 e	. .	225,093	. .

Source: Statistics Canada.
[1]Estimates reported by U.S. Bureau of Mines. [2]Shipments reported in annual reports of Aluminum Ltd.
e Estimated; p Preliminary; . . Not available; r Revised.

reacting hydrofluoric acid with carbon tetrachloride or with chloroform.

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. One and two-third tons of fluorspar are required for each ton of uranium processed into uranium hexafluoride.

Metallurgical grade. Approximately one 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 due to a combination of increased steel output and changing technology. Steelmakers have shifted increasingly from the basic open-hearth process to the basic oxygen process. The latter process consumes from 10 to 15 pounds of metallurgical-grade fluorspar compared with 3 to 5 pounds in the open-hearth process. The electric furnace process consumes from 8 to 10 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. It is anticipated that within the next decade older basic open-hearth furnaces will be replaced by the more efficient new basic oxygen or electric furnaces. Faced with possible shortages of metallurgical-grade fluorspar, the steel industry will attempt to find methods to reduce consumption of fluorspar. In addition, in some instances major consumers have become involved in exploration for fluorspar reserves. As yet, no satisfactory substitute for fluorspar as a fluxing agent in steelmaking has been found and indications are that the growth of metallurgical-grade reserves will not keep pace with requirements. Consequently, steelmakers may have to switch to higher-grade, higher-cost material, produced as flotation concentrates in pellet or briquette form. World consumption in the steel industry is forecast to increase from a current level of 2 million metric tons to 3.3 million metric tons in 1975. 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 opacifer in enamels and opal glass. It is also used to a limited extent, in the manufacture of clear glass as an active flux, a contributor to the gloss and as a decolourizer. Much of this grade of fluorspar concentrate could be used for the manufacture of hydrofluoric acid or as pellets and briquettes for steelmaking.

Canadian consumption

Most fluorspar consumed in Canada and virtually all domestic production is used in the manufacture of artificial cryolite (Na_3AlF_6) for the electrolytic reduction of alumina to aluminum.

Almost all fluorspar consumed domestically outside of the aluminum industry is imported. Preliminary figures for 1971 indicate that imports increased more than twofold over the previous year to 225,093 tons valued at $10,769,000. This increase in imports reflects reduced output of domestic fluorspar because of a 5-month strike at Alcan's Newfoundland Fluorspar Works. Imports from Mexico and Britain increased substantially and Italy and Spain supplied fluorspar to Canada for the first time in more than a decade. Imports from the United States decreased slightly from the previous year. Mexico provided 70 per cent of the total imports.

Prior to 1957, a large portion of Canadian production was exported to the United States and Europe. In 1958 exports declined abruptly owing to the development of alternative low-cost deposits in Mexico by large consumers in the United States.

World review

In 1971 total world fluorspar output is estimated to have reached 4.8 million short tons.

Increasing demand for fluorspar is worldwide and has led to many new and enlarged producing facilities in the last few years. The ability of fluorspar producers to increase capacity has resulted in a more or less balanced supply-demand relationship although markets in some areas remain tight.

Table 3. World fluorspar production 1969-70

	1969	1970
	(st)	(st)
Mexico	1,089,417	1,079,000
U.S.S.R.	440,000	..
Spain	353,000	..
France	330,693	..
Thailand	328,000	..
Italy	284,490	..
People's Republic of China	275,000	..
Britain	220,000	..
United States	182,567	269,000
Republic of South Africa	165,650	229,000
Canada	110,000	137,000
West Germany	101,743	..
Other countries	292,991	2,886,000
Total	4,173,551	4,600,000

Source: U.S. Bureau of Mines *Minerals Yearbook, 1969*, and U.S. Commodity Data Summaries, January 1972. . . Not available.

Mexico continued to rank as the world's largest supplier with an estimated output of 1.23 million tons in 1971. Although fluorspar mining began in Mexico in the early 1920's, the industry received its greatest stimulus during World War II 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 largest of these, accounting for some 40 per cent of total Mexican output is the Las Cuevas mine. This underground operation is an affiliate of Noranda Mines Limited. Other companies operating in Canada that have deposits in Mexico include Allied Chemical Corporation and Alcan. The rapid growth of fluorspar production in Mexico from 474,000 tons in 1963 to an estimated 1.23 million tons in 1971 has paralleled consumption increases in the United States which relies upon Mexico for virtually all import requirements.

The United States is the world's largest consumer and is heavily reliant on imports to meet demand. In 1971 producer shipments were 270,000 tons and imports from Mexico were 790,000 tons. Most output in the United States comes from the Illinois-Kentucky district and is produced by two companies; Ozark-Mahoning Company and Minerva Oil Company.

In France, expansion of the industry continues with several new mining and milling developments under way. New deposits are being worked in central France and in the Massif Central and Alpine regions.

A temporary setback in production in Spain because of mining development problems in 1970 was to have been corrected during 1971 and output is estimated at 300,000 tons for the year. 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.

Production in Britain expanded considerably during 1971 with the commissioning of the new Hopton works of C. E. Guilini (Derbyshire) Limited and other developments. Production is estimated to have reached 290,000 tons in 1971.

Expansions and new development in mining and milling in Italy, principally in Sardinia, have substantially increased the country's output.

The U.S.S.R. is the world's second largest producer of fluorspar and, in conjunction with other states in the Soviet bloc, produced about 650,000 tons in 1971. The People's Republic of China and North Korea together produce approximately 300,000 tons per year.

One of the fastest developing new sources of fluorspar in the world is Thailand with output in 1971 estimated at 360,000 tons, more than double the output in 1967. Reserves are not yet accurately determined but are believed to be substantial. Large reserves in the upper reaches of the River Kwai have recently been outlined and are slated for development possibly with Japanese participation. Japan is Thailand's principal customer. 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.

South Africa's output has more than doubled since 1968 and continues to grow. South America until recently produced limited quantities of hand-sorted metallurgical grade. At the present time, exploration and development is moving along at a rapid pace in both Brazil and Argentina and large increases in output are anticipated within the next few years.

Outlook

Both steel and primary aluminum production are increasing throughout the world. In 1975 steel production may reach 750 million metric tons, up 175 million metric tons from a current production level of approximately 575 million metric tons. Based on this forecast and on anticipated changes in methods of steel production, fluorspar consumption in this industry alone is forecast to reach 3.3 million metric tons in 1975, twice that consumed in 1968. Consumption in the aluminum industry is expected to reach 1 million metric tons by 1975. Even though it is anticipated that the largest growth in consumption will be related to increased steel production, significant growth is expected in some sectors of the chemicals industry. By 1975 world requirements for fluorspar are likely to exceed 6 million metric tons a year, requiring the mining of some 15 million tons of ore a year. Estimates of world reserves vary widely from 70 to 150 million tons. These reserves must be considered marginal for future requirements and considerable efforts are being made to expand both production and reserves to meet ever-growing consumer demands. As a measure of growing concern, in late 1969, the National Research Council in the United States formed a special panel to study available reserves of world fluorspar and fluorine as well as U.S. consumer needs for the next ten years. There is much concern among major consumers in the United States over long-range supplies, as reserves in Mexico have not been growing at a rate commensurate with forecast consumption rates.

The insatiable appetite of world steel furnaces, aluminum smelters and chemical complexes has provided sufficient incentive for industry to reassess known fluorspar occurrences in Canada. Exploration activities during 1971 achieved encouraging results notably in the Liard River area of northern British Columbia but also on the Burin Peninsula in Newfoundland where the potential for new discoveries is high.

Prices

United States fluorspar prices, quoted in Engineering and Mining Journal of December 1971
(net ton fob Illinois and Kentucky, CaF_2 content, bulk)

		($)
Ceramic, calcite and silica variable, CaF_2		
88-90%		75
95-96%		76.50-80
97%		85
In 100-lb paper bags, extra		6
Metallurgical, pellets, 70%, effective CaF_2		68.50
Acid, dry basis, 97% CaF_2		
Carloads		78.50-85
Less than carloads		78.50-85
Bags, extra		6
Pellets, 90% effective		76.50
Wet filter cake, 8-10% moisture, sold dry content – subtract approx.		2.50
Dry acid concentrates fob Wilmington, 97% CaF_2st		82.50
European wet filter cake, 8-10% moisture, sold dry content, duty pd. st cif Wilmington/Philadelphia, term contracts (spot material $5-10 higher)	(*n*)	72.50-73.50
Mexican		
Metallurgical 70% fob cars, Mexican border		47.33-49.33
Tampico, fob vessel		48.33-50.33
Acid, 97%+ Eagle Pass, bulk		62 -67

n = nominal.

Tariffs

Item No.		
Canada		
29600-1	Fluorspar	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: The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division. Tariff Schedules of the United States, Annotated (1971), T.C. Publication 344.

Gold

J. J. HOGAN

The downward trend in the production of gold in Canada since 1961 continued in 1971. A further decline is expected in 1972.

Gold production in 1971 was estimated at 2,243,000 fine ounces troy* valued at $79,268,000 based on the average Royal Canadian Mint price for the year compared with 2,408,574 ounces in 1970 valued at $88,057,464. The largest gold production in Canada for any year was recorded in 1941 when 5,345,179 ounces valued at $205,789,392 were produced. Since World War II the largest production was reached in 1960 when 4,628,911 ounces valued at $157,151,527 were produced.

The 1971 decrease in production was caused mainly by the closure of auriferous-quartz (lode) mines, a reduction in the tonnage of base-metal ores mined in the Noranda area of Quebec and a strike at the operations of Hudson Bay Mining and Smelting Co., Limited at Flin Flon, Manitoba.

In 1971 lode gold mines produced 1,749,000 ounces of gold compared with 1,883,764 in 1970, a decrease of 7.2 per cent. Nine gold mines, with a combined production of about 100,000 ounces in 1971, closed due to exhaustion of ore reserves. These mines produced about 200,000 ounces in 1970. One new mine commenced production.

Gold produced from base-metal mining amounted to 490,000 ounces compared with 517,451 ounces in 1970, a decrease of 5.3 per cent. Gold produced from this source accounted for 21.8 per cent of the Canadian production compared with 21.5 per cent in 1970.

Ontario continued as the leading gold-producing province in 1971, accounting for 50 per cent of the national total. Quebec was in second place with 29.0 per cent followed by the Northwest Territories with 13.6 per cent and British Columbia with 3.7 per cent.

World gold production in 1970 was estimated at 47.36 million ounces by the U.S. Bureau of Mines, compared with 46.53 million ounces in 1969. The Republic of South Africa produced 32.16 million ounces in 1970. This was 67.9 per cent of the world production or over 78 per cent of noncommunist world production. The U.S.S.R. produced an estimated 6.5 million ounces.

Canada has been one of the world's leading producers of gold. Since production was first officially recorded in 1858, Canada has produced 193.7 million ounces to the end of 1971 valued at $6,315 million. Although most provinces have been contributors to the total, Ontario, Quebec, British Columbia, Yukon Territory and Northwest Territories, in that order, have been the leaders.

Since 1948, a large segment of the gold mining industry has received financial assistance from the Government of Canada under the provisions of the Emergency Gold Mining Assistance Act. The Act was extended for two and a half years to June 30, 1973, receiving royal assent on February 11, 1971.

In 1971 a total of 30 lode gold mines operated in Canada. With the exception of two mines which were ineligible for assistance, the mines sold all or part of their production to the Royal Canadian Mint and were eligible for assistance payments on the ounces sold to the Mint. The price of gold on the London free market increased from an average price of $37.87 (U.S.) an ounce for January to $43.47 for December. As the price increased it became more profitable for some of the mines to sell their gold on the free market rather than sell to the Mint and obtain assistance on the ounces sold. Only four of the mines operating at the end of 1971 sold all their gold to the Mint.

*When used in this review, the term "ounce" refers to the troy ounce.

Table 1. Canada, production of gold, 1970-71

	1970	1971^p
	(ounces)	
Newfoundland, base-metal mines	6,811	4,000
New Brunswick, base-metal mines	5,120	5,000
Quebec		
Auriferous quartz mines		
Bourlamaque-Louvicourt	183,549	181,000
Malartic	195,658	197,000
Chibougamau	385	–
Noranda	53,987	19,000
Total	433,579	397,000
Base-metal mines	269,436	254,000
Total, Quebec	703,015	651,000
Ontario		
Auriferous quartz mines		
Kirkland Lake	87,073	76,000
Larder Lake	138,720	138,000
Porcupine	489,625	470,000
Red Lake and Patricia	314,226	341,000
Sudbury	13,819	–
Thunder Bay	34,702	–
Total	1,078,165	1,025,000
Base-metal mines	83,877	97,000
Total, Ontario	1,162,042	1,122,000
Manitoba-Saskatchewan, base-metal mines	79,531	54,000
Alberta, placer operations	152	–
British Columbia		
Auriferous quartz mines	39,300	21,000
Base-metal mines	61,509	62,000
Placer operations	388	1,000
Total, British Columbia	101,197	84,000
Yukon		
Base-metal mines	11,043	14,000
Placer operations	6,819	3,000
Total, Yukon	17,862	17,000
Northwest Territories		
Auriferous quartz mines	332,720	306,000
Base-metal mines	124	–
Total, Northwest Territories	332,844	306,000
Canada		
Auriferous quartz mines	1,883,764	1,749,000
Base-metal mines	517,451	490,000
Placer operations	7,359	4,000
Total	2,408,574	2,243,000
Total value	$88,057,464	$79,268,000
Average value per oz	$36.56	$35.34

Source: Statistics Canada, basic data; breakdown by types of operations by Statistics Section, Mineral Resources Branch.
^{p}Preliminary; – Nil.

A minor amount of gold was recovered from placer operations, mainly in the Yukon Territory.

Operations at producing mines

Atlantic provinces. All gold produced in the Atlantic provinces in 1971 was recovered as a byproduct of base-metal mining. Gold production totalled 9,000 ounces compared with 11,931 in 1970. The decrease in production was due mainly to a strike at the Buchans mine of American Smelting and Refining Company in Newfoundland. Heath Steele Mines Limited, in New Brunswick, was the largest producer in 1971.

Quebec. Gold production in Quebec in 1971 amounted to 651,000 ounces compared with 703,015 in 1970, a decrease of 7.4 per cent. Both the lode gold mines and byproduct base-metal mines recorded a decrease in production. The latter accounted for 39.0 per cent of the provincial gold total as against 38.3 per cent in 1970. The principal producers of byproduct gold are the base-metal mines of the Chibougamau and Noranda districts.

Eight lode gold mines operated in the province in 1971; three closed because of exhaustion of ore reserves and rising cost of production.

Auriferous-Quartz Mines. Bourlamaque-Louvicourt district. Two lode gold mines operated in the district in 1971. Production at Lamaque Mining Company Limited decreased by a small margin as compared with 1970. Ore reserves are limited and the mine is

Table 2. World gold production, 1969-70

	1969	1970^{p}
	(ounces)	
North America		
Canada	2,545,109	2,338,454
United States	1,733,176	1,743,322
Other countries	310,333	304,930
Total	4,588,618	4,386,706
South America		
Colombia	218,872	201,500
Brazil	176,938	180,076
Peru	131,641	104,258
Bolivia	49,854	30,603
Chile	59,102	50,718
Other countries	34,753	38,332
Total	671,160	605,487
Europe		
U.S.S.R.^{e}	6,250,000	6,500,000
Yugoslavia	84,074	97,384
France	54,946	58,000
Other countries	82,641	81,801
Total	6,471,661	6,737,185
Asia		
Philippines	571,145	602,715
Japan	246,492	255,759
Korea	210,734	211,345
India	109,473	104,200
Other countries	89,310	89,537
Total	1,227,154	1,263,556
Africa		
Republic of South Africa	31,275,882	32,164,107
Ghana	706,621	703,858
Southern Rhodesia	480,000^{e}	500,000^{e}
Republic of Zaire	175,804	177,128
Other countries	101,741	62,160
Total	32,740,048	33,607,253
Oceania		
Australia	699,223	617,000
Fiji	91,572	103,785
New Guinea	25,857	23,798
Other countries	10,717	11,283
Total	827,369	755,866
World total	46,526,010	47,356,053

Sources: U.S. Bureau of Mines *Minerals Yearbook* Preprint 1970, and for Canada, Statistics Canada.
^{p}Preliminary; ^{e}Estimated.

expected to close in 1972. Sigma Mines (Quebec) Limited reported a small increase in production in 1971, compared with 1970.

Malartic district. Three lode gold mines operated in the district in 1971, one less than in 1970. Production was slightly higher than in 1970.

Production at Camflo Mines Limited, the largest lode gold producer in the province in 1971, showed a small increase compared with 1970. The shaft was deepened 450 feet to a depth of 2,760 feet and three levels were established. Normal development was curtailed while this program was underway. Production at East Malartic Mines, Limited increased by 17.2 per cent in 1971 compared with 1970, mainly because of an increase in the tonnage of ore treated. Production in 1970 was affected by a strike of about one month's duration. Marban Gold Mines Limited had limited ore reserves and was expected to close in 1971. The mine was successful in finding extensions to ore zones and was able to extend the life of the operation into 1972. Production was slightly lower than in 1970. Marban was the only mine in 1971 shipping ore to the custom mill of Malartic Gold Fields (Quebec) Limited.

Noranda district. Closures of lode gold mines were responsible for a sharp decline in gold production. All three gold mines operating in the district, Kerralda Mines Limited and Wasamac Shaft No. 1 and 2 of Wright-Hargreaves Mines, Limited suspended operations in the first half of the year.

The Quemont base-metal mine of Kerr Addision Mines Limited exhausted its reserves and closed in the latter part of the year. This property produced a substantial amount of byproduct gold.

Ontario. Sixteen lode gold mines operated in the province in 1971, one less than in 1970. Five mines closed during the year and one commenced production. Gold produced from lode mines accounted for 91.4 per cent of the provincial total. Lode gold production decreased by 4.9 per cent from 1970.

Auriferous-Quartz Mines. Kirkland Lake district. Two lode gold mines operated in the district in 1971, the same number as in 1970. Ore reserves at Upper Canada Mines, Limited were exhausted and the mine closed in the latter part of the year. The mine came into production in 1938. Despite an increase in the grade of ore treated, the mine suffered a substantial decrease in the production of gold because the tonnage of ore treated declined by 47 per cent from 1970. The mill was kept in operation to treat copper-gold ore from its wholly owned subsidiary, Upper Beaver Mines Limited. This mine has been a substantial contributor to gold production of base-metal ores and is scheduled for closure early in 1972. On December 31, 1970 Macassa Gold Mines Limited amalgamated with Willroy Mines Limited and other related companies to form Willroy Mines Limited. In March 1971, Willroy leased the mining rights on the adjoining property to the west from Tegren Goldfields Limited and on the adjoining property to the east from Lamaque Mining Company Limited. Considerable exploratory and development work was carried out on the Tegren ground. A combination of high-grade ore from the Tegren mine and better-grade ore from Macassa resulted in an increase in gold production of about 26 per cent as compared with 1970.

Larder Lake district. Kerr Addison Mines Limited was the only operating lode gold mine in the district. Production in 1971 was slightly higher than in1970.

Porcupine district. At the end of 1971 there were five operating lode gold mines in the district, one less than at the end of 1970. Aunor Gold Mines Limited with a vein-type of deposit of moderate width, has successfully introduced the use of mobile stope-drill jumbos for drilling and the smaller load-haul-dump units for mucking. Increased tonnage mined was responsible for a small increase in production. Shortage of experienced labour adversely affected the operation of Dome Mines Limited resulting in a decrease in production in 1971 of about 6 per cent from 1970. To offset, in part, the price-cost squeeze, Dome modified mining procedures wherever possible in order to take advantage of technological advances in stope equipment. At the end of April Pamour Porcupine Mines, Limited leased the adjoining property of Hallnor Mines, Limited. Pamour continued to mine the remaining reserves and treated the ore at the Hallnor mill. Production of gold at the Ross mine of Hollinger Mines Limited was increased by a good margin by treating better-grade ore and improvement in recovery. This property has limited reserves. Operations of the gold and copper sectors at McIntyre Porcupine Mines Limited were normal for the year. Total gold production was slightly higher than in 1970. Metallurgical problems, which were solved, adversely affected the operations of the Pamour mine. The use of LHD units was increased at this property.

Red Lake mining division. Four lode gold mines were operating in the district at the end of 1971. Three mines closed during the year and one commenced production. Cochenour Willans Gold Mines, Limited and the related operations of Annco Mines Limited and Wilmar Mines Limited exhausted their ore reserves and closed in the last half of the year. Ore from Annco and Wilmar was mined through extensions of the underground workings of Cochenour and custom treated at its mill. Production of gold at Campbell Red Lake Mines Limited, the largest lode gold producer in Canada, increased by about 9.6 per cent over 1970. The mine was not eligible for assistance under the terms of the Emergency Gold Mining Assistance Act, the only other property in this category being Robin Red Lake Mines Limited. The main production shaft was deepened 426 feet. The shaft-deepening program which began in 1970 advanced the shaft by a total of 1035 feet, establishing five new levels (23-27), a crusher station and loading pockets. Dickenson Mines Limited custom-milled ore from Robin Red Lake and this was partly responsible for a substantial reduction in the ore milled at the Dickenson mine. Better grade of ore mined enabled Dickenson to maintain production near the 1970 level. The Robin Red Lake mine came into production in the last half of the year. The ore is mined by Dickenson through extensions of the workings from its adjoining property. Production target for Robin has been set at 100 tons a day. Production at Madsen Red Lake Gold Mines Limited increased by 9.7 per cent despite a substantial decrease in the tons milled. Better grade of ore from the new No. 8 zone was largely responsible for the improvement in production. The mine has limited reserves.

Base-metal Mines. Byproduct gold played a minor role in production of gold in Ontario. It was recovered from the nickel-copper ores of the Sudbury area and the copper-zinc ores at Manitouwadge. McIntyre Porcupine in Timmins and Upper Beaver near Kirkland Lake produced appreciable gold from copper-gold ores. The latter is scheduled for closure early in 1972.

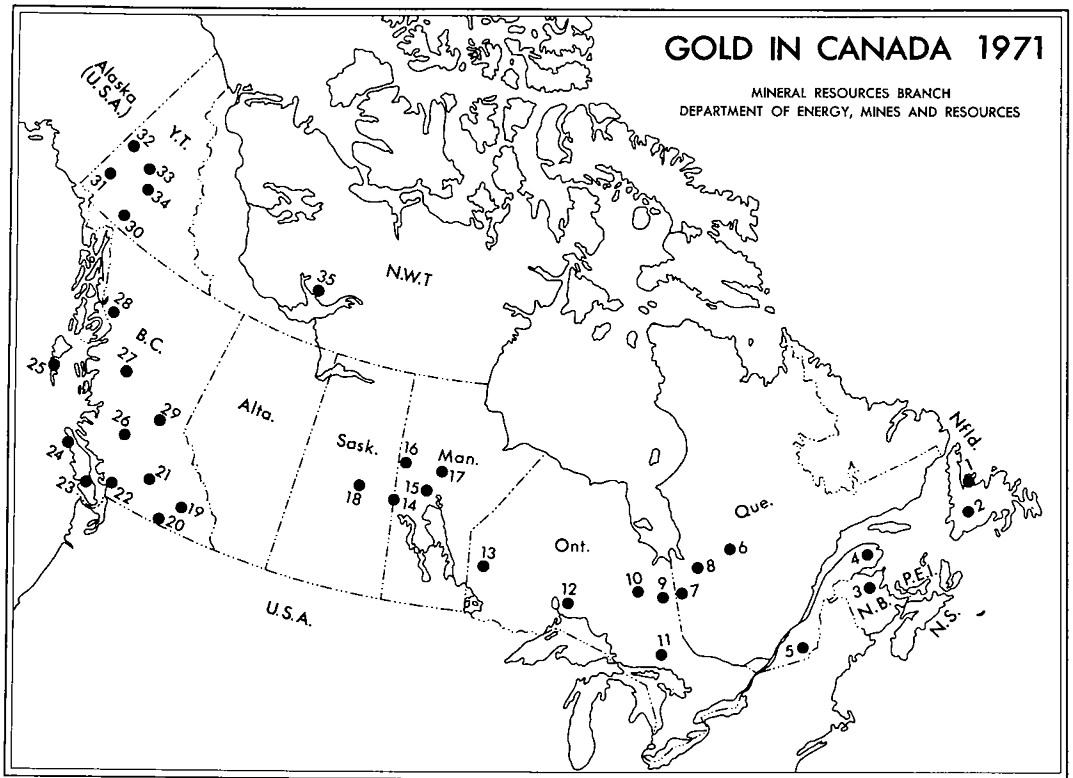
Prairie Provinces. Virtually all gold produced in the Prairie Provinces was recovered as a byproduct from the mining of base-metal ores. Production in 1971 was estimated at 54,000 ounces compared with 79,683 ounces in 1970. A strike at the plants of Hudson Bay Mining and Smelting Co., Limited was largely responsible for the decline in production. Hudson Bay recovered byproduct gold from its operations in the Flin Flon and Snow Lake areas. Sherritt Gordon Mines, Limited recovered gold from its operations in the Lynn Lake district. Some byproduct gold was recovered from the nickel-copper ores of The International Nickel Company of Canada, Limited at Thompson. Anglo-Rouyn Mines Limited, near Lac La Ronge in Saskatchewan, recovered byproduct gold from its copper ore.

Some gold is recovered by gravel washing plants on the North Saskatchewan River near Edmonton, Alberta.

British Columbia. An era of lode gold mining in British Columbia came to an end in September 1971, with the closure of the mine of Bralorne Can-Fer Resources Limited in the Bridge River area. Production at this property began in 1932.

A small amount of gold was recovered from the placer deposits in the province.

The main source of byproduct gold was derived from the treatment of copper ores. Production in 1971 amounted to 62,000 ounces compared with 61,509 ounces in 1970. The Phoenix Copper Division of The Granby Mining Company Limited, Granisle Copper Limited and Western Mines Limited were the main producers of byproduct gold. With the expansion of copper production, especially from the porphyry type of ore zones, the production of byproduct gold should increase.



Yukon Territory. Gold production in the Yukon in 1971 was estimated at 17,000 ounces, about the same as in 1970. Substantially lower production was recovered from the placer operations. Venus Mines Ltd., near Carcross, closed its silver-gold-zinc property in June 1971. Whitehorse Copper Mines Ltd. (formerly New Imperial Mines Ltd.) suspended milling operations until ore becomes available on the completion of an underground development program. The base-metal mining operation of Anvil Mining Corporation Limited produced some gold.

Placer gold was produced by small operators in the Dawson, Mayo and Kluane Lake districts.

Northwest Territories. Five gold mines, all located near the town of Yellowknife, operated in the Territories in 1971. Production was estimated at 306,000 ounces compared with 332,844 ounces in 1970. The combined operations of Con Mine of Cominco Ltd. and Rycon Mines Limited reported a small increase in total gold produced. An increase in production at Con was offset by a lower production at Rycon. Gold produced by Giant Yellowknife Mines Limited was below that of 1970 partly because of increased tonnage mined from the related properties of Lolor Mines Limited and Supercrest Mines Limited. These companies are contiguous to Giant and the ore was mined through extension of the underground workings of Giant. The ore is custom treated at its mill. Both companies recorded an increase in production.

New property developments

Very little exploratory work was carried out on gold prospects because of the generally unfavourable economic conditions for gold mining.

Uses

Gold has been used traditionally as a monetary measure by governments and central banks in the settlement of international balances. In recent years the commercial demand for gold from industry and the arts has greatly increased. The International Monetary Fund estimated that gold consumed in the world for industrial and artistic purposes had increased from $780 million (U.S.) funds in 1966 to $975 million in 1970. Estimated consumption for the first quarter of 1971 was $290 million (U.S.).

Gold producers, 1971
(Numbers refer to numbers on the map)

Newfoundland
1. Consolidated Rambler Mines Limited (*a*)
2. American Smelting and Refining Company (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*)
   The Patino Mining Corporation (Copper Rand Mines Division) (*a*)
7. *Noranda-Rouyn district*
   Delbridge Mines Limited (*a*)
   Falconbridge Copper Limited (Lake Dufault Division) (*a*)
   Kerr Addison Mines Limited (Quemont) (*a*)
   Kerralda Mines Limited (*b*)
   Noranda Mines Limited (*a*)
   Wright-Hargreaves Mines, Limited (Wasamac No. 1 and No. 2 mines) (*b*)
   Malartic district
   Camflo Mines Limited (*b*)
   East Malartic Mines, Limited (*b*)
   Marban Gold Mines Limited (*b*)
   Bourlamaque-Louvicourt district
   Lamaque Mining Company Limited (*b*)
   Manitou-Barvue Mines Limited (*a*)
   Sigma Mines (Quebec) Limited (*b*)
   Duparquet district
   Kerr Addison Mines Limited (Normetal) (*a*)
8. *Matagami district*
   Mattagami Lake Mines Limited (*a*)
   Orchan Mines Limited (*a*)

Ontario
9. *Larder Lake district*
   Kerr Addison Mines Limited (*b*)
   Kirkland Lake district
   Upper Beaver Mines Limited (*a*)
   Upper Canada Mines, Limited (*b*)
   Willroy Mines Limited (Macassa Division) (*b*)
10. *Porcupine district*
   Aunor Gold Mines Limited (*b*)
   Dome Mines Limited (*b*)
   Hallnor Mines, Limited (*b*)
   Hollinger Mines Limited (Ross) (*b*)
   McIntyre Porcupine Mines Limited (*a*) (*b*)
   Pamour Porcupine Mines, Limited (*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. *Red Lake Mining Division*
   Annco Mines Limited (*b*)
   Campbell Red Lake Mines Limited (*b*)
   Cochenour Willans Gold Mines, Limited (*b*)
   Dickenson Mines Limited (*b*)
   Madsen Red Lake Gold Mines Limited (*b*)
   Robin Red Lake Mines Limited (*b*)
   Wilmar Mines Limited (*b*)

Manitoba
14. Hudson Bay Mining and Smelting Co., Limited (*a*)
15. Hudson Bay Mining and Smelting Co., Limited (Snow Lake) (*a*)
16. Sherritt Gordon Mines, Limited (Fox Lake) (*a*)
17. The International Nickel Company of Canada, Limited (Thompson)

Saskatchewan
14. Hudson Bay Mining and Smelting Co., Limited (*a*)
18. Anglo-Rouyn Mines Limited (*a*)

British Columbia
19. Cominco Ltd. (*a*)
20. The Grandby Mining Company Limited (Phoenix Copper Division) (*a*)
21. Bethlehem Copper Corporation Ltd. (*a*)
   Brenda Mines Ltd. (*a*)
22. Texada Mines Ltd. (*a*)
23. Western Mines Limited (*a*)
24. Coast Copper Company, Limited (*a*)
   Utah International Inc. (Island Copper Mine) (*a*)
25. Wesfrob Mines Limited (*a*)
26. Bralorne Can-Fer Resources Limited (Bralorne Division) (*b*)
27. Granisle Copper Limited (*a*)
28. Granduc Operating Company (*a*)
29. Small placer operations (*c*)

Yukon Territory
30. Venus Mines Ltd. (*d*)
   Whitehorse Copper Mines Ltd. (*a*)
31. Small placer operations (*c*)
32. Small placer operations (*c*)
33. Small placer operations (*c*)
34. Anvil Mining Corporation Limited (*a*)

Northwest Territories
35. Cominco Ltd. (Con Mine) (*b*)
   Giant Yellowknife Mines Limited (*b*)
   Lolor Mines Limited (*b*)
   Rycon Mines Limited (*b*)
   Supercrest Mines Limited (*b*)

(*a*) Base-metal; (*b*) Auriferous quartz; (*c*) Placer; (*d*) Silver-gold.

Table 3. Canada, gold production, 1962-71

	Auriferous Quartz Mines		Placer Operations		Base-metal Ores		Total	
	(oz)	(%)	(oz)	(%)	(oz)	(%)	(oz)	(%)
1962	3,494,821	83.6	57,760	1.4	625,815	15.0	4,178,396	100
1963	3,324,907	83.1	57,905	1.4	620,315	15.5	4,003,127	100
1964	3,151,593	82.2	58,512	1.5	625,349	16.3	3,835,454	100
1965	2,958,874	82.1	44,598	1.2	602,559	16.7	3,606,031	100
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^p	1,749,000	78.0	4,000	0.2	490,000	21.8	2,243,000	100

Sources: Statistics Canada. Breakdown classification by Statistics Section, Mineral Resources Branch.
^{p}Preliminary.

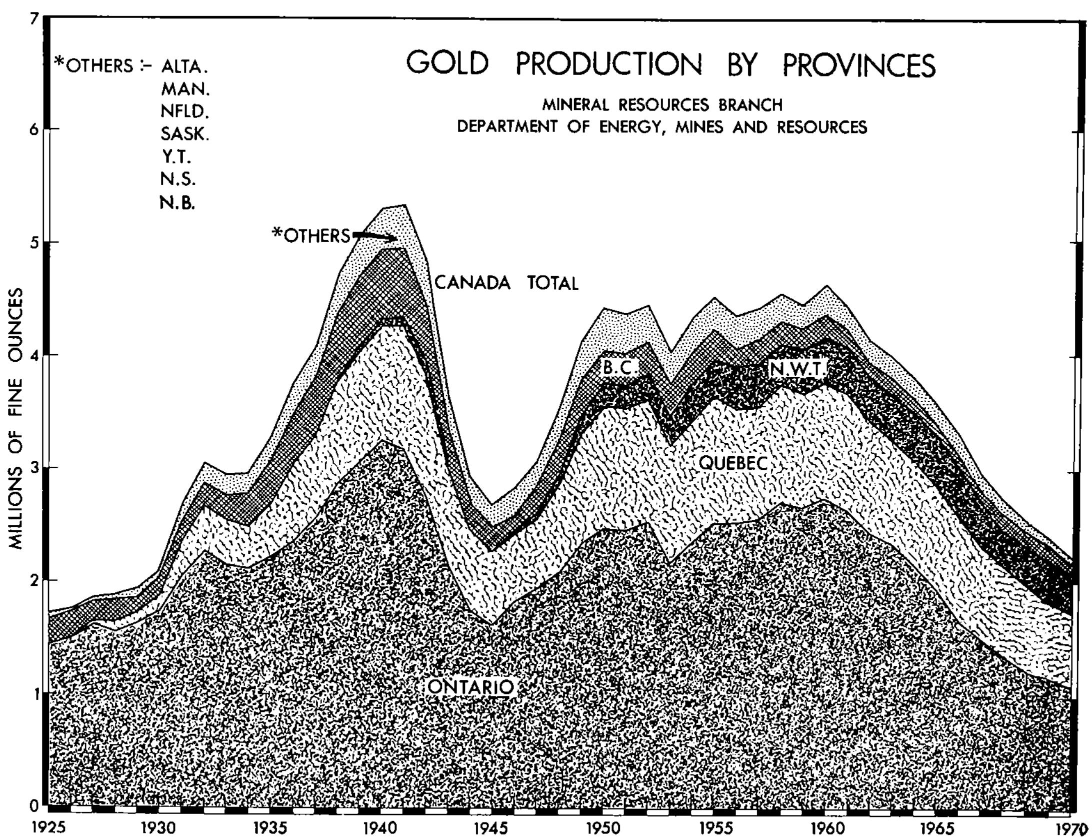


Table 4. Canada, gold production, average value per ounce and relationship to total value of all mineral production, 1962-71

	Total Production	Total Value	Average Value per Ounce	Gold as Percentage of Total Value of Mineral Production
	(oz)	($ Cdn)	($ Cdn)	(%)
1962	4,178,396	156,313,794	37.41	5.5
1963	4,003,127	151,118,045	37.75	5.0
1964	3,835,454	144,788,388	37.75	4.3
1965	3,606,031	136,051,943	37.73	3.7
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^p	2,243,000	79,268,000	35.34	1.3

Source: Statistics Canada. ^{p}Preliminary.

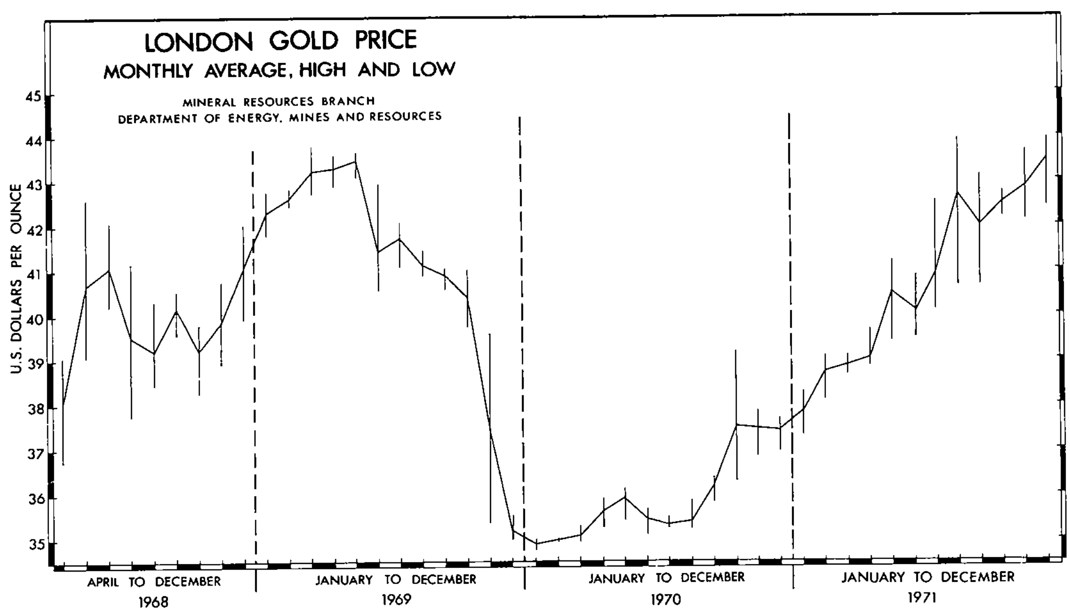
The jewellery or artistic trade accounted for over 70 per cent of the gold consumed by industry. The electrical and electronic industry and dentistry are other major consumers of gold.

Prices

The average price paid for gold by the Royal Canadian Mint in 1971 was $35.34 a fine ounce. This compared with $36.56 in 1970 and $37.69 in 1969. The Mint purchased gold at $35 (U.S.) an ounce. The Canadian dollar was allowed to float in the international exchange markets on May 31, 1970. The result of this action was an increase in the value of the Canadian dollar in relation to the U.S. dollar and was responsible for the lower price paid for gold by the Mint in 1970 and 1971. The Mint price varied between a high of $35.83 in June to a low of $34.89 in December.

In 1971 the price of gold on the London gold market varied from a low of $37.325 (U.S.) an ounce in January to a high of $43.975 (U.S.) in December.

With the purpose of offsetting a continuing large deficit in the United States balance of payments, President Nixon on August 15, 1971 announced the imposition of a 10 per cent surcharge on a large number of imports. At the same time convertibility of the U.S. dollar into gold was suspended. At a meeting of the finance ministers of the Group of Ten at the Smithsonian Institution, Washington, D.C., an agreement was reached on December 18, 1971, for the realignment of their currencies. The United States was to devalue its currency 7.89 per cent by raising the official price of gold from $35 (U.S.) to $38 an ounce. Approval by the U.S. Congress will be required for an increase in the official U.S. gold price. With the exception of Canada, new central exchange rates were set for each member country. The Canadian dollar was allowed to continue to float in the foreign exchange markets. Fluctuations in the currencies from the new central parity rates were to be increased from 1 per cent to 2.25 per cent. The 10 per cent surcharge was also removed.



Gypsum and Anhydrite

D. H. STONEHOUSE

Gypsum is a hydrous calcium sulphate ($CaSO_4 \cdot 2H_2O$) 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.

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. Over 70 per cent of Canadian gypsum production is exported to the United States. The value of total construction in Canada in 1971 was estimated at $15.6 billion, about 30 per cent of which was credited to residential building construction. Work stoppages occurred in the construction industry, but as mortgage money became more readily available during the latter half of the year, residential construction prospered. Housing unit starts were recorded in excess of 230,000 representing an all-time, one-year gain of over 20 per cent.

In 1971 crude gypsum production increased to 6,800,000 tons, exports increased by about 4 per cent to over 5 million tons and imports, mainly from Mexico to the west coast, were increased to nearly 106,000 tons. Nearly all Nova Scotian production was exported to the United States while most of the output from other provinces was used regionally in Canada in the manufacture of gypsum products and portland cement.

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 sheets of absorbent 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. Production of gypsum wallboard, lath and sheathing increased by 287,455,659 square feet in 1971 and plaster production decreased by 12,196 tons.

Crude gypsum is also used in the manufacture of portland cement where it acts 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.

Canadian industry and developments

Atlantic provinces. During 1971 five companies produced crude gypsum in Nova Scotia, two in New Brunswick and one in Newfoundland. Regional consumption of raw gypsum was small compared to the quantity exported to the United States from the Atlantic provinces. Three cement manufacturing plants, two gypsum wallboard manufacturing plants and one plant producing plaster of paris, together used an estimated 100,000 tons. Crude gypsum from Nova

Scotia was used by Quebec wallboard plants and by Quebec and Ontario cement producers, each supplying regional construction industries.

Fundy Gypsum Company Limited, a subsidiary of United States Gypsum Company, Chicago, mined 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 was shipped to company-owned processing plants through the port of Hantsport, Nova Scotia.

National Gypsum (Canada) Ltd. produced gypsum from a quarry near Milford, Nova Scotia, and exported 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 were used to haul gypsum from the quarry site to Dartmouth, a distance of 30 miles. Company-owned, self-unloading ore carriers of up to 30,000 tons capacity were loaded at rates up to 5,000 tons per hour through facilities on Bedford Basin. Shipments were made also 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, mined gypsum from a quarry near River Denys, Inverness County, Nova Scotia. Crushed rock was transferred by rail to open storage at Point Tupper, 20 miles from the quarry, and loaded to chartered vessels through a conveyor and reclaim tunnel system. Shipments were exported mainly to the Georgia-Pacific plant at Wilmington, Delaware.

Table 1. Canada, gypsum production and trade, 1970-71

	1970		1971p	
	(short tons)	($)	(short tons)	($)
Production (shipments)				
Crude gypsum				
Nova Scotia	4,775,233	10,262,563	4,932,000	10,688,000
Newfoundland	491,354	1,467,449	600,000	1,710,000
Ontario	537,271	1,195,424	715,000	1,227,000
British Columbia	270,266	737,826	340,000	947,000
Manitoba	171,646	379,121	133,000	298,000
New Brunswick	72,753	157,032	80,000	173,000
Total	6,318,523	14,199,415	6,800,000	15,043,000
Imports				
Crude gypsum				
Mexico	38,000	124,000	102,700	390,000
United States	868	19,000	3,060	37,000
Other countries	12	...	23	2,000
Total	38,880	143,000	105,783	429,000
Plaster of paris and wall plaster				
United States	8,366	549,000	10,273	661,000
Britain	432	19,000	282	13,000
Other countries	–	–	16	2,000
Total	8,798	568,000	10,571	676,000
Gypsum lath, wallboard & basic products			(sq. ft.)	
United States	15,093	740,000	39,671,465	1,427,000
Britain	34	3,000	88,016	4,000
Total	15,127	743,000	39,759,481	1,431,000
Total imports, gypsum and gypsum products		1,454,000		2,536,000
Exports				
Crude gypsum				
United States	4,795,548	9,457,000	4,959,638	9,572,000
Bahamas	57,716	87,000	75,336	113,000
Britain	40	2,000	–	–
Total	4,853,304	9,546,000	5,034,974	9,685,000

Source: Statistics Canada.
pPreliminary; – Nil; . . . Less than $1,000.

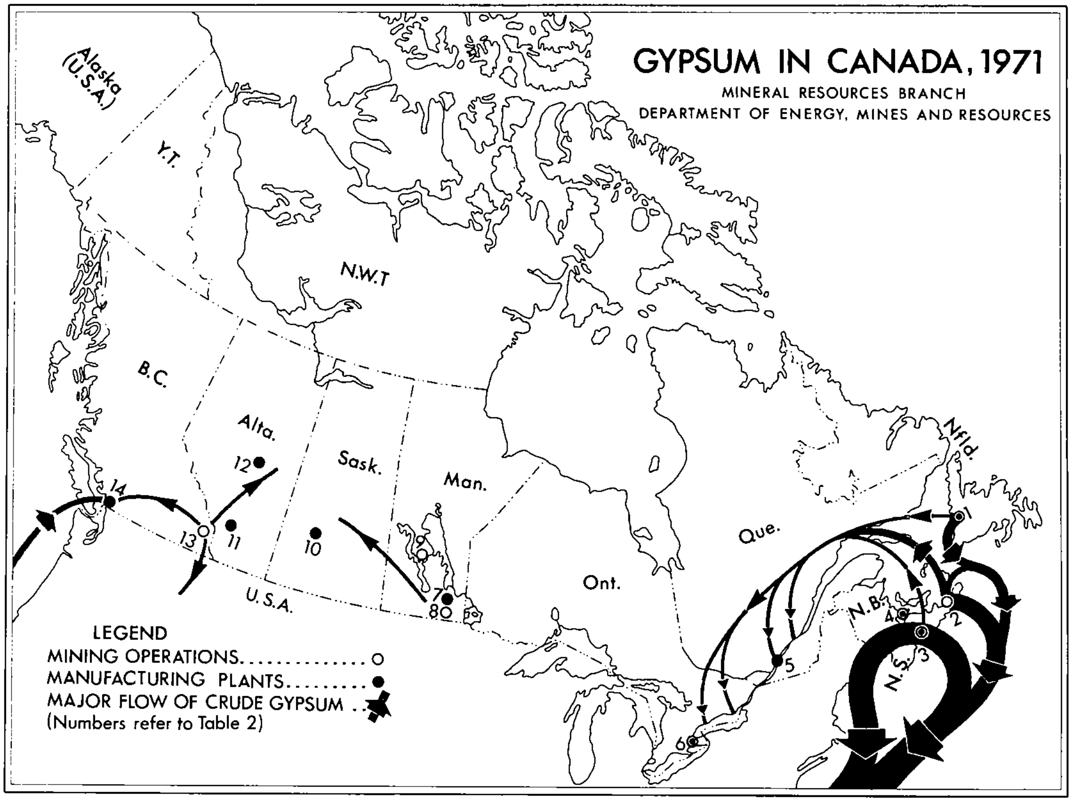


Table 2. Canada, summary of gypsum and gypsum products operations, 1971
(numbers refer to map)

Company	Location	Remarks
Newfoundland		
1. The Flintkote Company of Canada Limited	Flat Bay	Open-pit mining of gypsum
Atlantic Gypsum Limited	Corner Brook	Gypsum products manufactured
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
	Walton	Open-pit mining of gypsum and anhydrite
Domtar Construction Materials Ltd.	Mackay Settlement	Open-pit mining of gypsum
	Windsor	Gypsum plaster manufacture

Company	Location	Remarks
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
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
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
British Columbia		
13. Western Gypsum Mines Ltd.	Windermere	Open-pit mining of gypsum
14. Westroc Industries Limited	Vancouver	Gypsum products manufacture
Domtar Construction Materials Ltd.	Vancouver	Gypsum products manufacture

Little Narrows Gypsum Company Limited, another subsidiary of United States Gypsum Company, produced gypsum from a quarry at Little Narrows, Victoria County, Nova Scotia, for shipment to the United States, Quebec and Ontario, through company ship-loading facilities near the plant site. This is the source of raw gypsum for a new wallboard plant made operative in February, 1971 by Canadian Gypsum Company, Limited at St-Jérôme, 27 miles northwest of Montreal, Quebec.

At Walton, Hants County, Nova Scotia, gypsum and anhydrite were produced for National Gypsum (Canada) Ltd. by B. A. Parsons under contract. Shipments were made through the port of Walton to United States destinations.

Domtar Construction Materials Ltd. operated a calcining plant at Windsor, Nova Scotia, for the production of plaster of paris. Gypsum for the plant was 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 was mined at Flat Bay Station, Newfoundland, 60 miles southwest of Corner Brook, by The Flintkote Company of Canada Limited, mostly for export to company plants in the United States. Raw gypsum was 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 were made through the port of St. George's from an open stockpile supplied by an aerial cable tramway carrying rock from Flat Bay, 6 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 quarried gypsum during 1971. Canadian Gypsum Company, Limited, a subsidiary of United States Gypsum Company, produced gypsum for use in the manufacture of plaster and wallboard in the company-owned plant at Hillsborough. Canada Cement Lafarge Ltd. obtained gypsum from the Havelock area, west of Moncton, for use in the manufacture of portland cement at Havelock.

Other gypsum occurrences in the southeastern counties of New Brunswick have been recorded. On the Magdalen Islands in the Province of Quebec many gypsum outcrops occur.

Ontario. Two underground gypsum mines were operated in southwestern Ontario in 1971 to produce raw material for three gypsum products plants and a number of cement manufacturing plants. Domtar Construction Materials Ltd. mined gypsum at Caledonia, near Hamilton, from an 8-foot seam 75 feet below the surface. Crude gypsum was 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 was manufactured.

At Hagersville, southwest of Caledonia, Canadian Gypsum Company, Limited, a subsidiary of United States Gypsum Company, Chicago, produced crude gypsum by room and pillar mining methods from a 4-foot seam, reached through a 95-foot vertical shaft. Gypsum rock was shipped in crude form and was used also by the company in the production of wallboard and plaster in a plant adjacent to the mine shaft. The production capacity of the gypsum products plant was increased in 1969 by doubling the output potential of one wallboard line.

Gypsum has been proven at depths down 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 from one underground mine and one surface operation in Manitoba and from one surface operation in British Columbia during 1971. Gypsum products plants, situated in areas exhibiting major development trends were supplied from Canadian producers of gypsum rock. Imports, mostly from Mexico, supplied a number of cement producers.

Domtar Construction Materials Ltd. obtained crude gypsum from its quarry at Gypsumville, 150 miles northwest of Winnipeg, Manitoba. The company's gypsum products plant at Winnipeg used crude from this source.

Westroc Industries Limited mined gypsum from a deposit 140 feet beneath the surface near Silver Plains, 30 miles south of Winnipeg. Crushed and screened product was used by the company's gypsum products plant in Winnipeg and quantities were shipped to BACM Industries Limited's gypsum products plant at Saskatoon as well as to cement manufacturers in Winnipeg, Regina and Saskatoon.

Western Gypsum Mines Ltd., a subsidiary of Westroc Industries Limited, operated an open-pit mine near 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 and to cement manufacturers in the Vancouver area, Kamloops, Exshaw and Edmonton. Crude gypsum from Windermere is exported to cement manufacturers in northeastern 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.

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. World production was estimated at 56.8 million tons in 1971, over 50 per cent of which came from European countries. The major European producers in order of output were France, U.S.S.R., Britain, Spain, Italy and West Germany.

Table 3. World production of gypsum, 1970-71

	1970	1971[e]
	(thousand short tons)	
United States	9,436	9,647
Canada	6,318	6,800
France	6,711	6,800
Britain	4,712	4,800
Italy	3,417	3,500
Other Free World	17,179	17,500
Communist countries (except Yugoslavia)	7,683	7,800
World total	55,456	56,847

Sources: United States, Bureau of Mines, Commodity Data Summaries, January 1972, and for Canada, Statistics Canada.
[e] Estimated.

Table 4. Canada, gypsum production, trade and consumption, 1962-71
(short tons)

	Production[1]	Imports[2]	Exports[2]	Apparent Consumption[3]
1962	5,332,809	69,947	4,162,997	1,239,759
1963	5,955,266	74,628	4,703,118	1,326,776
1964	6,360,685	80,940	5,057,253	1,384,372
1965	6,305,629	75,433	4,746,638	1,634,424
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[p]	6,800,000	105,783	5,034,974	1,870,809

Source: Statistics Canada.
[1] Producers' shipments, crude gypsum. [2] Includes crude and ground, but not calcined. [3] Production plus imports minus exports.
[p] Preliminary.

The United States is the world's largest single producer and together with Canada brings North American production to near 30 per cent of world output. Asian producers accounted for about 12 per cent of the world total, the three major producers being Iran, India 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.

Interest in byproduct gypsum continued as companies explored the economics of producing wallboard, plaster and plaster-based blocks from the waste gypsum that results during the manufacture of phosphoric acid from phosphate rock. Sabina Industries Limited holds the Canadian and United States rights to a patented process (the Giulini process) for the recovery of high-quality gypsum from this type of waste product and recently announced negotiations were under way towards sublicensing the process in the U.S.

Production of sulphuric acid and coproduct cement from gypsum and anhydrite has been practised in European countries for a number of years.

Table 5. Canada, production of gypsum products 1970-71

Item		1970	1971
Wallboard	(square feet)	817,519,641	1,077,065,996
Lath		102,808,616	119,733,396
Sheathing		20,487,258	31,471,782
Plaster	(short tons)	151,730	139,534

Source: Statistics Canada.

Markets, trade and outlook

Gypsum and 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 in Canada. The long-established gypsum industry in Nova Scotia exists because efficient, large-volume, transportation facilities and favourable mining conditions and costs enable successful competition with inland United States operations. Canadian exports of crude gypsum are mainly to the eastern United States and are dependent on the building construction industry there. On the basis of projected percentage increases in the gross national product of the United States, exports of gypsum from Nova Scotia are expected to reach 6.5 million tons by 1975 and 9 million tons by 1980. Cumulative United States domestic demand for crude gypsum to the year 2000 has been estimated at 705 million tons.

Some raw gypsum is moved from the Atlantic provinces to Montreal and Toronto regions for use in gypsum products manufacture and in cement production. Raw gypsum is rail-hauled from near Winnipeg, Manitoba to Calgary, Alberta and to Saskatoon, Saskatchewan, and from Windermere, British Columbia to Calgary, Edmonton and Vancouver for gypsum products manufacture. Raw gypsum is imported on the west coast from Mexico, mainly for cement manufacture. Minor amounts of crude gypsum are shipped to the mid-United States for agricultural use, and quantities are exported to the northwestern United States from British Columbia, mainly for use by cement manufacturers.

Construction of homes, apartments, schools and offices will continue 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 price and ease of installation. 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 A82.20 to A82.35 relate to gypsum and gypsum products.

Anhydrite

Production and trade statistics for anhydrite are included with gypsum statistics. Anhydrite is produced by Fundy Gypsum Company Limited at Wentworth, Nova Scotia, by Little Narrows Gypsum Company Limited at Little Narrows, Nova Scotia and for National Gypsum (Canada) Ltd. by B. A. Parsons at Walton, Nova Scotia. According to the Nova Scotia Annual Report on Mines, production of anhydrite in 1970 was 301,163 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.

Tariffs

Canada

Item No.		British Preferential Tariff	Most Favoured Nation	General
29200-1	Gypsum, crude	free	free	free
29300-1	Plaster of paris, or gypsum calcined, end prepared wall plaster, the weight of the package to be included in the weight for duty per 100 pounds	free	6¢	12½¢
29400-1	Gypsum, ground not calcined	free	free	15%
28410-1	Gypsum tile	15%	15%	25%

United States

Item No.			
512.21	Gypsum, crude	free	
		On and After Jan. 1, 1971	On and After Jan. 1, 1972
512.24	Gypsum, ground calcined	71¢ per long ton	59¢ per long ton
245.70	Gypsum or plastic building boards and lath	7%	6%

Sources: The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa. Tariff Schedules of the United States (Annotated 1971) TC Publication 341.

Indium

D. B. FRASER

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.

Cominco Ltd. is the only Canadian producer of indium and is one of the world's largest producers. Its output in 1971 totalled 394,000 troy ounces; in 1970, output was 898,000 ounces.

Indium is produced in the United States, Japan, Peru, U.S.S.R. and West Germany, as well as in Canada. Statistics on output and consumption are not generally available.

Production

Indium was first recovered at Trail 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 the following year, 437 ounces were produced by laboratory methods. After several years of intensive research and development, production began in 1952 on a commercial scale. At present, the potential annual production at Trail is 1 million troy ounces, or about 35 tons.

Indium enters the Trail metallurgical plants with 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 retreated in the lead smelter. From the lead bullion, indium is removed in bullion dross. The dross is retreated 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 retreatment 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 high-purity grade (approximately 99.999 and 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 and a variety of fabricated forms such as discs, wire, ribbon, foil and sheet, powder and spherical pellets.

Properties and uses

Indium is a silvery-white, soft metal that resembles tin in its physical and chemical properties. Its chief characteristics are its extreme softness, its low melting point and high boiling point. It is easily scratched with the fingernail and can be made to adhere to other metals by hand-rubbing. It has a melting point of 156°C. Like tin, a rod of indium will emit a high-pitched sound if bent quickly. The metal has an atomic weight of 114.8; its specific gravity at room temperature is 7.31, which is about the same as that for iron.

Indium forms alloys with silver, gold, platinum and many of the base metals, improving their performance in certain special applications. Its first major use, still an important outlet, was in high-speed silver-lead bearings in which the addition of indium increases the strength, wettability and corrosion resistance of the bearing surface. Such bearings are used in aircraft piston engines, diesel engines and several types of automobile engines; the standard grade (99.97 per cent) is satisfactory for this purpose. Indium is used also in low-melting-point alloys containing bismuth, lead, tin and cadmium, for example a bismuth-tin-cadmium-lead-indium alloy containing 19.1 per cent indium used as a heat fuse melts at 47°C. Indium is also 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 1934, indium and its compounds are relatively new materials whose potential applications are still being explored. Uses have been found in electrical contacts, resistors, thermistors and photoconductors. Indium can be used as an indicator in atomic reactors since artificial radioactivity is easily induced in indium by neutrons of low energy. Indium compounds added to lubricants have been found to have a beneficial anticorrosive effect. Indium is used in certain very small lightweight batteries. Indium has possible applications in decorative plating of jewelry and tableware.

Foreign trade

Statistics on foreign trade are not generally available for indium. United States imports in 1971 totalled 344,663 troy ounces, obtained as follows: 160,018 ounces from Canada, 61,455 from The Netherlands, 38,223 from Japan, 27,031 from Peru, 22,787 from West Germany, 5,833 from Britain and 29,316 from the U.S.S.R.

Prices

Prices of indium as quoted in *Metals Week* remained unchanged during 1971 from those established September 19, 1968.

	($ per troy oz)
Sticks, 30-90 troy oz	2.50
Ingot, 100 troy oz	2.05
10,000+ troy oz	1.75

Iron Ore

P. LAFLEUR

Canadian iron ore shipments totalled an estimated 43.3 million tons* in 1971, down 4.5 million tons from 1970 when total shipments reached an all-time high. Exports were down by 5.1 million tons to 33.6 million tons while domestic shipments were up sharply by about 0.9 million tons to 9.7 million tons. Production exceeded shipments by 2.3 million tons and stocks at mines and ports, estimated to have contained 9.1 million tons at the end of 1970, went up accordingly.

The reduction in exports reflected mainly lower steel production in western Europe and the United States, Canada's largest markets, notwithstanding increased shipments to Japan. Imports, down 0.7 million tons to 1.4 million tons in 1971, were lower as the result of displacement of South American and African ores by domestic ores and the sale by a United States iron and steel producer, Jones & Laughlin Steel Corporation, of the Adams Mine to Dominion Foundries and Steel, Limited, which had the effect of converting 159,000 tons of exports to domestic shipments.

Iron ore consumption was down from 1970 by 0.7 million tons to 10.8 million tons and paralleled the lower pig iron production which was down 0.7 million net tons to 8.6 million net tons (Tables 3 and 4). However, steel production at 12.2 million net tons was down only 0.1 million tons from the year before. This disproportionate decrease compared to that for pig iron production is attributable to a decrease in the hot metal/scrap iron ratio and a slight increase in electric steel production using scrap. Blast furnace problems experienced by the three Ontario integrated producers rather than lack of demand accounted for the lower pig iron production. Domestic iron ore shipments plus imports exceeded consumption by 0.4 million tons and stocks at incoming docks and steel plants went up accordingly.

Development

Canadian annual iron ore production capacity at the end of 1971 totalled 47.31 million tons including 25.48 million tons of pellet and reduced iron capacity. The Canadian iron ore industry, which began a period of slow growth in 1969, added only 0.28 million tons in 1970 and 0.3 million tons in 1971. There was a loss of capacity in mid-1970 when Coast Copper Company, Limited closed its 80,000-ton-a-year iron ore recovery plant on Vancouver Island.

Falconbridge Nickel Mines Limited's 300,000-ton-a-year reduced iron ore plant began tuneup operations in early 1971 but at year-end was still encountering new process difficulties. The International Nickel Company of Canada, Limited announced in May 1971 that, as a result of new pollution abatement requirements coupled with increased construction costs and marketing factors, it would cancel the nearly completed 250,000-ton-a-year pellet plant expansion. Plans by Canadian Industries Limited to raise present sulphuric acid capacity of 875,000 tons a year by 700,000 tons were also cancelled. Furthermore, production of pellets, currently around 670,000 tons a year, well below International Nickel's rated capacity of 850,000 tons a year, will decrease to 600,000 tons to meet the new Ontario regulations with respect to sulphur dioxide emissions.

Three major projects in Quebec and Labrador were under construction during 1971: a 10.0-million-ton-a-year expansion of Iron Ore Company of Canada's Labrador City concentrator in Newfoundland-

*The long or gross ton (2,240 pounds) is used throughout unless otherwise stated.

Table 1. Canada, iron ore production and trade, 1970-71

	1970		1971[p]	
	(long tons)[1]	($)	(long tons)[1]	($)
Production (shipments)				
Newfoundland	21,035,166	292,582,028	20,179,000	287,261,000
Ontario	10,561,015	144,765,483	10,079,000	142,828,000
Quebec	13,435,490	133,891,759	11,304,000	112,754,000
British Columbia	1,677,275	17,391,883	1,719,000	16,936,000
Total	46,708,946	588,631,153	43,281,000	559,779,000
Byproduct iron ore[2]	876,000		924,000[e]	
Imports				
United States	1,973,793	26,806,000	1,272,047	17,589,000
Brazil	143,754	1,301,000	89,618	1,090,000
West Germany	48	1,000	29	. . .
Australia	8,000	120,000	–	–
Total	2,125,595	28,228,000	1,361,694	18,679,000
Exports				
Iron ore, direct shipping				
United States	5,141,544	49,380,000	4,113,714	40,278,000
Britain	1,372,590	12,795,000	1,280,975	9,128,000
Italy	507,003	3,965,000	517,485	3,870,000
Belgium and Luxembourg	286,601	2,591,000	43,888	427,000
Other countries	401,557	3,872,000	–	–
Total	7,709,295	72,603,000	5,956,062	53,703,000
Iron ore, concentrates				
United States	6,289,788	68,856,000	4,260,295	46,908,000
Japan	1,950,581	18,025,000	2,969,511	26,032,000
Netherlands	1,418,268	11,136,000	1,729,509	13,677,000
Britain	1,886,110	14,484,000	1,659,534	13,397,000
West Germany	1,630,949	12,448,000	1,229,180	9,948,000
France	78,274	574,000	154,862	1,265,000
Finland	84,646	622,000	79,848	633,000
Belgium and Luxembourg	125,684	948,000	41,644	305,000
Bahamas	6,001	63,000	14,896	161,000
Total	13,470,301	127,156,000	12,139,279	111,326,000
Iron ore, agglomerated				
United States	12,339,154	193,427,000	11,186,071	178,479,000
Britain	1,659,374	26,441,000	1,720,159	27,586,000
Italy	1,095,144	17,530,000	976,098	15,682,000
Spain	129,101	2,053,000	588,109	9,513,000
Netherlands	1,347,731	21,260,000	256,100	4,107,000
Japan	223,644	3,426,000	130,394	2,107,000
France	177,341	2,727,000	41,580	667,000
Belgium and Luxembourg	133,200	2,122,000	22,760	364,000
Other countries	370,945	5,839,000	–	–
Total	17,475,634	274,825,000	14,921,271	238,505,000
Iron ore, not elsewhere specified				
United States	71,368	1,160,000	536,844	9,123,000
Britain	–	–	53,414	506,000
Nigeria	–	–	17,410	169,000
Japan	5	. . .	–	–
Total	71,373	1,160,000	607,668	9,798,000

Table 1 (cont'd)

	1970		1971p	
	(long tons)[1]	($)	(long tons)[1]	($)
Total export all classes				
United States	23,841,854	312,823,000	20,096,924	274,789,000
Britain	4,918,074	53,720,000	4,714,082	50,617,000
Japan	2,194,365	21,640,000	3,099,905	27,139,000
Netherlands	3,108,176	35,689,000	1,985,609	17,784,000
Italy	1,602,147	21,495,000	1,493,583	19,552,000
West Germany	2,001,894	18,287,000	1,229,180	9,948,000
Spain	129,101	2,053,000	588,109	9,513,000
France	294,860	3,691,000	196,442	1,932,000
Belgium and Luxembourg	545,485	5,661,000	108,292	1,096,000
Finland	84,646	622,000	79,848	633,000
Nigeria	–	–	17,410	168,000
Bahamas	6,001	63,000	14,896	161,000
Total	38,726,603	475,744,000	33,624,280	413,332,000

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 Resources Branch from data supplied by companies. Total iron ore shipments includes shipments of byproduct iron ore.
pPreliminary; – Nil; eEstimated; . . . Less than $1,000.

Labrador; a new 6.0-million-ton-a-year concentrator and pellet plant at Sept-Îles, Quebec, by the same company; and a new 16-million-ton-a-year concentrator at Mt. Wright, Quebec, by Quebec Cartier Mining Company.

By September 1, about 15 per cent of the construction had been completed on the Sept-Îles beneficiating and pelletizing complex. Expected to start production in 1972 and to reach capacity in early 1973, the facilities will produce annually 6 million tons of pellets, averaging about 65 per cent iron and less than 5 per cent silica, from 8.0 to 9.5 million tons of friable crude ore grading 52 per cent iron. The beneficiation plant, using wet semiautogenous peripheral discharge grinding mills, cyclone classification, two-stage screening, and cationic flotation, was designed from pilot plant studies conducted at Schefferville since 1962. The 10.0-million-ton-a-year expansion of the Carol concentrator, now at 12.0 million tons, of which about 11 million tons will continue to be pelletized, was about 25 per cent completed by September 1 and is expected to be in production in September or October of 1972. At the Sept-Îles terminal, an extension to the new dock to handle ships up to 260,000 tons and new handling and storage facilities are expected to be completed in 1972. The cost of the expansion of the concentrator at Labrador City, the concentrating and pelletizing complex at Sept-Îles, and the expansion of the common services at the Sept-Îles terminal will be approximately $350 million; together these projects will create 3,000 construction jobs and 1,300 new permanent jobs.

Construction of Quebec Cartier Mining Company's Mt. Wright project 75 miles northeast of Gagnon and 25 miles southwest of Labrador City was well under way in 1971. The concentrator, scheduled to start up in 1974 but only reaching full production capacity by 1976, will have an annual capacity to treat about 40 million tons of specular hematite averaging 32 per cent iron to recover 16 million tons of concentrate grading 66 per cent iron. A railroad spur starting near Gagnon at mile 170 and extending 88 miles to Mt. Wright that will enable trains to be operated at construction speeds as early as the fall of 1972, is expected to be completed in 1973. Site clearing and foundation building were commenced in 1971 and a 16-mile portion of a 27-mile road was completed in late 1971 to connect Labrador City to Mt. Wright. The project will cost over $300 million and create 5,000 construction and 2,000 permanent jobs.

At a site 15 miles west of Labrador City, a new community for 5,000 people is being constructed. The town, called Fermont, will incorporate a concept not seen in most northern communities which have tended to be carbon copies of southern Canadian cities with large heating systems being the only concession to climatic differences. The town-houses, detached and semidetached houses, will be systems-built and transported to the site. To provide shelter from prevailing winds the community will have a wind-screen structure incorporating a specially insulated three-storey and five-storey apartment complex of 350 units. Connected to the apartment by a climate-controlled walkway will be a shopping centre, restaurant, swimming pool, arena, library and town hall. A compact street plan will minimize distances to services and shopping, and houses will be sited to receive maximum sun.

By early 1976, ore from the Lac Jeannine mine at Gagnon is expected to be depleted and the company has stated that feed for the concentrator could come from the Fire Lake mine, when it is developed, some 35 miles northeast and near the new Mt. Wright spur line. However, production capacity of the concentrator would be reduced to 5.0 million tons a year from 8.5 million tons because of the finer grind required for the new ore.

At least 20 companies were active in 1971 in the geological, metallurgical and economic evaluation of iron ore deposits and/or in the seeking of markets and financing. As in the past few years, most activities were centred in Quebec-Labrador and Ontario. Little exploration activity was reported by companies with properties in British Columbia. The several factors responsible for decreased activity in that province include the prevalence of small orebodies with a short life that can only be mined at high unit cost and in severe competition from foreign ores. The viability of British Columbia's only two producers depends on the added income from byproduct or coproduct copper concentrate.

Production and shipments*

Production of iron ore including byproduct ore totalled 45.7 million wet tons in 1971 compared with 47.0 million wet tons in 1970 and 37.0 million wet tons in 1969. Iron ore and byproduct ore was produced by 17 companies at 18 locations with 10 operations in Ontario, three in British Columbia, two in Quebec, two in Newfoundland (Labrador) and one in Quebec-Labrador.

All the provinces except British Columbia had decreased shipments in 1970 (Table 1). Quebec, the second largest producer, recorded the largest loss with shipments of 11.3 million dry tons, down 2.1 million tons from the previous year, followed by Newfoundland with 20.2 million dry tons, down 2.1 million tons. Ontario shipments were down fractionally by 0.4 million tons to 10.1 million dry tons and those from British Columbia were at the 1970 level of 1.7 million dry tons.

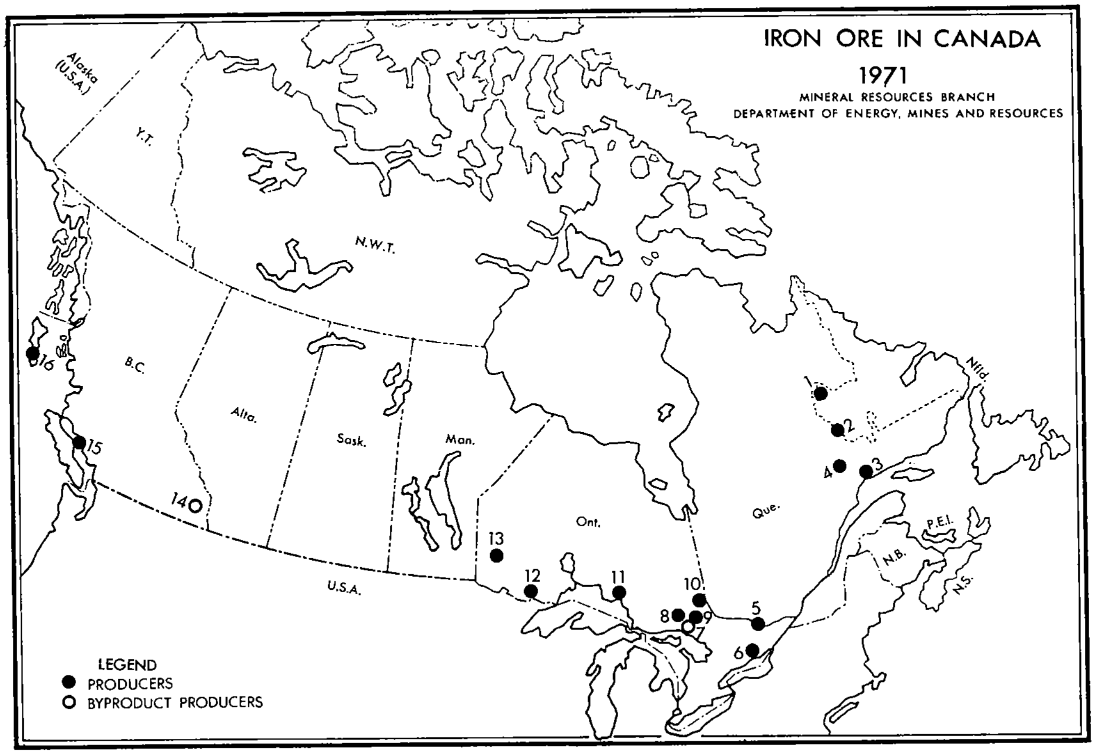
*Mineral Resources Branch for all data except for provincial statistics obtained from Statistics Canada.

In Quebec and Labrador, production exceeded shipments and stocks were up by 2.3 million tons at the mines and shipping ports. Shipments from Iron Ore Company of Canada, the largest Canadian producer, were down 2.9 million tons from 1970 and totalled 17.2 million tons comprised of 9.5 million tons of pellets, 5.9 million tons of direct-shipping ore (from both Quebec and Labrador) and 1.8 million tons of concentrate. Canada's second largest producer, Quebec Cartier Mining Company, operated at capacity rate but shipped only 7.9 million tons compared with 8.9 million tons the year before. After completing modifications to its regrind mill from wet to dry, Wabush Mines reached capacity production of 6.1 million tons for the first time, but shipments were only 100,000 tons above the 1970 level of 5.5 million tons. The Hilton Mines, a Quebec producer about 40 miles from Ottawa and the only Quebec iron mine not on the Labrador Trough, operated at slightly above capacity rate during the year, but shipments at 869,000 tons were fractionally lower than in 1970 when shipments were made also from stockpile.

In the Atikokan area of Ontario, Caland Ore Company Limited closed part then all of its operations from about August 15 to October 24 because of very low demand from its United States parent, Inland Steel Company, which takes all the output. As a result, shipments were down by 0.6 million tons to 1.5 million tons comprised of 0.9 million tons of pellets and 0.6 million tons of Warren Coarse sized ore. To assist employees on layoff and accelerate company training, training programs under the Adult Occupational Training Act of Ontario were conducted on a full-time basis. The recognition of social responsibility is yet another sign of a maturing mining industry that could well be adopted by others in the industry and in other sectors. The other producer in the Atikokan area, Steep Rock Iron Mines Limited, operated at above capacity rate and some 1.4 million tons of pellets were shipped. For the first time since the mine began production in 1944 no "red ore" or direct-shipping ore was shipped. Underground mining that was resumed in 1970 on an experimental basis to tap known resources beneath the open pits was continued in 1971.

At other Ontario iron mines operations in 1971 were either at or slightly below capacity production rates. The Adams Mine, which was purchased July 31, 1971, by Dominion Foundries and Steel, Limited (Dofasco) from the United States iron and steel producer, Jones & Laughlin Steel Corporation, shipped 1.1 million tons of which 0.9 million tons were exports and 0.2 million tons were domestic shipments. Cliffs of Canada Limited, a wholly owned subsidiary of The Cleveland-Cliffs Iron Company, and the managing agent of Dofasco's Sherman Mine, operates this property. The acquisition, together with Dofasco's major interests in the Sherman Mine and Wabush Mines, provides the company with its entire requirements of iron ore from Canadian sources. The Griffith Mine, which installed fine screening to improve quality and throughput in 1971, shipped some 1.4 million tons, down fractionally from 1970, while the Sherman Mine shipped all-rail some 1.0 million tons to Dofasco. Both Marmoraton Mining Company Division of Bethlehem Chile Iron Mines Company and National Steel Corporation of Canada, Limited, operated at capacity and shipped 475,000 tons and 690,000 tons, respectively, all to the United States.

In British Columbia, both Wesfrob Mines Limited and Texada Mines Ltd. operated at capacity and some 1.2 million tons and 475,000 tons were shipped. Wesfrob Mines was reported to be diamond drilling



Producers
(numbers refer to numbers on map)

1. Iron Ore Company of Canada (Schefferville)
2. Iron Ore Company of Canada (Labrador City) Scully Mine of Wabush Mines (Wabush)
3. Pointe Noire Division of Wabush Mines (Pointe Noire)
4. Quebec Cartier Mining Company (Gagnon)
5. The Hilton Mines (Shawville)
6. Marmoraton Mining Company, Division of Bethlehem Chile Iron Mines Company (Marmora)
8. National Steel Corporation of Canada, Limited (Capreol)
9. Sherman Mine of Dominion Foundries and Steel, Limited (Temagami)
10. Adams Mine of Dominion Foundries and Steel, Limited (Kirkland Lake)
11. Algoma Ore Division of The Algoma Steel Corporation, Limited (Wawa)
12. Caland Ore Company Limited (Atikokan) Steep Rock Iron Mines Limited (Atikokan)
13. The Griffith Mine (Bruce Lake)
15. Texada Mines Ltd. (Texada Is.)
16. Wesfrob Mines Limited (Moresby Is.)

Byproduct producers

7. Falconbridge Nickel Mines Limited (Falconbridge)
   a. Pyrrhotite Plant
   b. Iron-Nickel Refinery
   The International Nickel Company of Canada, Limited (Copper Cliff)
14. Cominco Ltd. (Trail)

Table 2. Canada, iron ore producers[1], 1970 and 1971

Company and Property Location	Participating Companies	Material Mined and/or Treated	Product Shipped	Shipments 1970	Shipments 1971
		(% Fe natural)	(% Fe dry)	('000 long tons)	
Adams Mine; Boston Twp., near Kirkland Lake, Ont.	Dominion Foundries and Steel, Ltd. (acquired Adams Mine from Jones & Laughlin Steel Corporation, July 30, 1971); managed by Cliffs of Canada Limited, a wholly owned subsidiary of The Cleveland-Cliffs Iron Company	Magnetite from open pit mine (20)	Pellets (65)	1,173	1,036
Algoma Ore Division of The Algoma Steel Corp., Ltd.; mines and sinter plant near Wawa, Ont.	Wholly owned	Siderite from open pit and underground mines (33)	Siderite sinter (50)	1,529[2]	1,628[3]
Caland Ore Co. Ltd.; E. arm of Steep Rock Lake, near Atikokan, Ont.	Inland Steel Co.	Hematite and goethite from open pit mine (54)	Pellets (63) Concentrate (59)	1,086 1,057	859 612
Coast Copper Co., Ltd.[4]; Benson L., northern Vancouver Is., B.C.	Cominco Ltd.	Chalcopyrite and magnetite from underground mine (30)	Magnetite concentrate (65)	77	–
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 (32)	Pellets (66)	1,503	1,364
Hilton Mines, The; near Shawville, Quebec, 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 (36)	Pellets (67)	1,030	869
Iron Ore Company of Canada 1. Schefferville, Que., operation	Labrador Mining and Exploration Co. Ltd., 4.73%; Hollinger Mines Ltd., 10.17%; The Hanna Mining Co. (managing agent), 26.37%, Armco Steel Corp., 5.87%; Bethlehem Steel Corp., 18.80%; Youngstown Sheet and Tube Company[5], 5.87%; National Steel Corp., 17.62%; Republic Steel Corp., 5.87%; Wheeling-Pittsburgh Steel Corp., 4.70%	Hematite-goethite-limonite from open pit mines (54)	Direct-shipping ore (59)	7,625	5,922
2. Carol Lake, Labrador, operation[6]		Specular hematite and some magnetite from open pit mines	Pellets (65) Concentrate (65)	10,535 1,948	9,476 1,795

Table 2. (cont'd)

Company and Property Location	Participating Companies	Material Mined and/or Treated	Product Shipped	Shipments 1970	1971
		(% Fe natural)	(% Fe dry)	('000 long tons)	
Marmoraton Mining Co., Division of Bethlehem Chile Iron Mines Company; near Marmora, Ont.	Bethlehem Steel Corp.	Magnetite from open pit mine (21^e)	Pellets (65)	465	474
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 (64)	663	681
Quebec Cartier Mining Co.; Gagnon, Quebec	United States Steel Corp.	Specular hematite from open pit mine (33)	Specular hematite concentrate (66)	8,870	7,864
Sherman Mine; near Temagami, Ontario	Dominion Foundries and Steel, Limited, 90%; Tetapaga Mining Company Ltd. (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 (25)	Pellets (65)	914	1,026
Steep Rock Iron Mines Ltd.; Steep Rock Lake, N. of Atikokan, Ont.	Publicly owned company	Hematite-goethite from open pit mine (51^e)	Concentrate (59) Pellets (63)	47 1,435	5 1,411
Texada Mines Ltd.; Texada Island, B.C.	Kaiser Aluminum and Chemical Corp.	Magnetite and chalcopyrite from underground mines (34)	Magnetite concentrate (66)	467	512
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[5], 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 (31)	Pellets (66)	5,478	5,597

Table 2. (cont'd)

Company and Property Location	Participating Companies	Material Mined and/or Treated	Product Shipped	Shipments 1970	1971
		(% Fe natural)	(% Fe dry)	('000 long tons)	
Wesfrob Mines Limited; Tasu Harbour, Moresby Is., Queen Charlotte Is., B.C.	Falconbridge Nickel Mines Limited	Magnetite and chalcopyrite from open pit mines (39)	Pellet-feed concentrate (70)	604	727
			Sinter-feed concentrate (61)	370	528
Byproduct producers					
Cominco Ltd.; Kimberley, B.C.	Publicly owned company	Pyrrhotite flotation concentrates roasted for acid production; calcine sintered	Iron oxide sinter (65) is processed into pig iron at plant	146[7]	47[7]
Falconbridge Nickel Mines Ltd.; Falconbridge, Ont.	Publicly owned company	Pyrrhotite flotation concentrates treated	Calcine (67)	63	82
The International Nickel Co. of Canada, Ltd.; Copper Cliff, Ont.	Publicly owned company	Pyrrhotite flotation concentrates treated	Pellets (67)	667[e]	796
Quebec Iron and Titanium Corp.; mine at Lac Tio, Que.; electric smelter at Sorel, Que.	Kennecott Copper Corp.; Gulf & Western Industries, Inc. (The New Jersey Zinc Co.)	Ilmenite-hematite ore (40% Fe, 35% TiO_2) from open pit mine at Lac Tio, beneficiated and calcined at Sorel	Calcine smelted by electric smelting to TiO_2 slag, and various grades of desulphurized pig iron or remelt iron	1,571[8]	1,580[e8]

Sources: Company reports, personal communications and others.
[1]Exclusive of Craigmont Mines Limited which ships magnetite byproduct concentrate to western Canada coal preparation plants. [2]Including 626,000 tons of superfluxed sinter, and 1,695 tons of crude ore shipped to the U.S.A. to be used as a food supplement in the livestock industry. [3]Comprising 1,539,648 tons of superfluxed sinter, 86,393 tons of regular sinter and 2,237 tons of crude ore shipped to the U.S.A. to be used as a food supplement in the livestock industry. [4]Iron recovery plant no longer operating. [5]Operating subsidiary of Lykes-Youngstown Corporation. [6]The assets of the Carol Pellet Company, which was established to pelletize concentrates produced by IOC, were acquired by IOC on December 31, 1970. [7]Sinter consumed in pig iron production. [8]Ilmenite calcine smelted.
[e]Estimated; – Nil.

from an adit in 1971 to delineate a probable underground orebody west of the present open pit and to test favourable ground southwest of the pits.

The two Sudbury area byproduct producers, The International Nickel Company of Canada, Limited and Falconbridge Nickel Mines Limited shipped 796,000 tons and 82,000 tons, both up slightly from 1970. Falconbridge's 300,000-ton-a-year reduced iron ore plant began tuneup operations in early 1971, but at year-end, was still encountering new process difficulties. International Nickel announced that, as a result of new pollution requirements coupled with increased construction costs and marketing factors, it would cancel the nearly completed 250,000-ton-a-year pellet plant expansion. Furthermore, the company said that it would decrease the production of pellets to 600,000 tons a year to meet the new Ontario regulations with respect to sulphur dioxide emissions. In British Columbia, Cominco Ltd. consumed only 45,000 tons of iron oxide sinter in the production of pig iron compared with 146,000 tons in 1971. The company reported that the largest furnace, of 200-ton capacity, was out of commission during the year leaving only the 100-ton furnace operational; several alternatives are under consideration by the company.

Trade

Exports during the year totalled 33.6 million tons compared with 38.7 million tons in 1970. The reduction in exports reflected lower steel production in western Europe and the United States, Canada's largest markets, notwithstanding increased shipments to Japan. Another contributing factor to the lower exports was the sale by a United States iron and steel producer, Jones & Laughlin Steel Corporation, of the Adams Mine to Dominion Foundries and Steel, Limited, which had the effect of converting 159,000 tons of exports to domestic shipments.

Table 3. Production and capacity of pig iron and crude steel at Canadian iron and steel plants, 1970-71

	1970	1971p
	(short tons)	
Pig Iron		
Production	9,085,955	8,615,756
Capacity at December 31	11,335,000	10,907,000
Steel Ingots		
Production	12,346,132	12,169,552
Capacity at December 31	14,083,375	15,461,125

Source: Statistics Canada, Primary Iron and Steel.
pPreliminary.

Table 4. Receipts, consumption and stocks of iron ore at Canadian iron and steel plants, 1970-71

	1970	1971p
	(long tons)	
Receipts imported	2,092,000	1,338,703[1]
Receipts from domestic sources	9,438,000	9,937,193[2]
Total receipts at iron and steel plants	11,530,000	11,275,896
Consumption of iron ore	11,473,953	10,837,974
Stocks of ore at iron and steel plants, December 31	4,140,629	4,527,314
Change from previous year	+79,882	+386,685

Source: American Iron Ore Association, compiled from company submissions.
[1]Compared to 1,272,047 tons in Table 1. [2]Compared to 9.7 million tons estimated by Mineral Resources Branch.
pPreliminary.

The largest market, the United States, took 20.1 million tons (compared with 23.8 million tons in 1970) followed by the ECSC with 5.0 million tons (7.5 million tons) and Britain with 4.7 million tons (4.9 million tons). Shipments to France, which began in 1969, were down slightly from 1970 to 196,000 tons while those to Spain, which became an importer of Canadian iron ore for the first time in 1970, were up sharply from 129,000 tons to 588,000 tons. Exports to Japan were up by 0.9 million to 3.1 million tons and reflected the increasing importance of shipments by the east coast producers, Iron Ore Company of Canada and Quebec Cartier Mining Company. The west coast producers, Wesfrob Mines Limited and Texada Mines Ltd., continued to ship all their output to Japan except for a small amount (122,000 tons in 1971) that went to the reduced iron ore plant of Midland-Ross Corp. in Oregon.

The trend towards lower imports accelerated in 1971 as they declined an estimated 0.7 million tons to 1.4 million tons (Table 1), which is a new low in modern times. Several factors contributed to the decrease but the most important were a displacement of South American and African ores by domestic ores, and the sale by the United States iron and steel producer, Jones & Laughlin Steel Corporation of the Adams Mine to Dominion Foundries and Steel, Limited, which converted some exports to domestic shipments thereby decreasing import demand.

The United States provided the bulk of imports in 1971 with 1.3 million tons all of which were consigned to the three integrated iron and steel producers in Ontario. Most of this tonnage went to The Steel Company of Canada, Limited through its 10-per-cent interest in The Erie Mining Company, a 10.3-million-ton-a-year pellet producer in Minnesota. Small tonnages of merchant ore are usually shipped to the three producers either for slagging purposes or to cover shortfalls in supply. However, the Algoma Steel Corporation, Limited is usually a net exporter having sufficient supply and Dominion Foundries and Steel, Limited after its purchase of the Adams Mine in 1971 has said that it too is now self-sufficient. Some 70,000 tons of Brazilian ore went to the Sydney Steel Corporation in Nova Scotia, but Labrador-Quebec ores have largely supplanted foreign ores in this market.

The level of imports is expected to remain at 1.4 million tons until 1974 when it is expected to rise to at least 3.0 million tons. It was announced that The Algoma Steel Corporation, Limited and The Steel Company of Canada, Limited will participate in a joint venture with The Cleveland-Cliffs Iron Company and others in the development of the Tilden Mine, a 4-million-ton-a-year pellet project near Marquette, Michigan. Algoma will take 1.2 million tons a year with delivery to begin in 1974 to supply a new blast furnace anticipated to be in operation at that time. Through its joint participation, Stelco will obtain 400,000 tons a year to replace shipments from its half-owned Hilton Mine, which will be largely depleted of its ore reserves by then.

Consumption

Iron ore consumption was down from 1970 by 0.7 million tons to 10.8 million tons and paralleled the lower pig iron production which was down 0.5 million net tons to 8.6 million net tons (Tables 3 and 4). However, steel production at 12.2 million net tons was down only 0.1 million net tons from the previous year. This disproportionate decrease compared to that for pig iron production is attributable to a decrease in the hot metal/scrap iron ratio and a slight increase in electric steel production using scrap. Blast furnace problems experienced by the three Ontario integrated producers rather than lack of demand accounted for the lower pig iron production. Domestic iron ore shipments at 9.7 million tons (9.9 million tons in Table 4) and imports at 1.4 million tons exceeded consumption by 0.4 million tons and stocks at incoming docks and steel plants went up accordingly.

World iron ore production, trade and consumption

The U.S.S.R., most east European countries and Spain were the only major exceptions in an otherwise worldwide decrease in crude steel production in 1971 as total output fell by 16 million net tons or by about 2.4 per cent to an estimated 642 million net tons. Crude steel production fell 11 million net tons to 121 million tons in the United States, 6 million net tons to 114 million net tons in the ECSC countries (with West Germany experiencing the greatest decline), 5.3 million net tons to 97.6 million net tons in Japan, and 4.6 million net tons to 26.6 million net tons in Britain. The U.S.S.R. gained first position among world steel producers in 1971 when it produced 133 million net tons of steel, up 5.3 million net tons from 1970. Minor reductions were also recorded by Canada (12.2 million net tons compared with 12.3 million net tons in 1970), India, Finland and Sweden; minor gains were made by Spain, Brazil, South Africa, Austria and most east European countries.

The world iron and steel industry demonstrated again in 1971, as it has done so many times since the end of World War II, its inability to match supply with demand, to the detriment of the world iron ore industry. While world iron ore consumption at an estimated 708 million tons was down some 17 million tons from 1970 to parallel the decline in world steel production, a nonconcomitant fall in shipments from 741 million tons to 733 million tons, resulted in a buildup of inventories at incoming ports and world steel plants. Added to the 17 million tons estimated to have been overbooked in 1970, total stocks may have approximated 42 million tons at year-end, almost all imports and all in Japan, western Europe and the United States. A world iron ore production of 762 million tons compared to 751 million tons in 1970 (*Metal Bulletin,* May 12, 1972) also indicates a buildup in inventory of some 30 million tons at mines and shipping ports.

The oversupply situation had its beginning in late 1969 when at the time of traditional renegotiation of iron ore contracts by western Europe, Swedish iron mines were closed by a labour strike. This aggravated an already tightened supply situation brought on by peak European steel production and decreased supplies from Canada. The strike helped to strengthen the bargaining position of most world suppliers to Europe who obtained price increases for 1970 delivery ranging from 10 to 15 per cent. Contracts that were signed for longer terms of two years and more to assure supply at prices no greater than what were newly agreed upon, resulted in overcommitment towards the end of 1970 and especially in 1971.

The situation in Japan began to develop about mid-1970 when crude steel production began to decline as a basic reflection of a similar and more pronounced decline in domestic steel demand. The policy of obtaining future supplies by means of long-term contracts works to Japan's advantage in expansionary times since it assures adequate supply and low guaranteed prices and it certainly works to the advantage of suppliers who have a guaranteed market and can raise capital for expansion based on these contracts. Not only did Japan not achieve its anticipated high growth rate in 1971, its production level was down some 5 million net tons from the previous year, and aggravated the excess iron ore stock situation that began to develop in mid-1970. Furthermore, it has now become abundantly clear that Japan will not be able to meet its production goal for 1972 and absorb the whole volume of iron ore contracted for, even if it took into consideration a full exercise of its option for a 10-per-cent decrease of purchase volume. Other means to reduce imports may be taken to reduce supplies such as renegotiation of contracts, re-export, diversion of exports, or pollution-motivated *force majeure*. Taking all the foregoing points into consideration, the outlook for the world iron ore industry does not appear good for 1972.

Markets and prices

International iron ore prices were generally mixed in 1971. In the North American market, Lake Erie base prices advanced by as much as 5 per cent to reflect increased production and transportation costs. Most European prices were at 1970 levels but some prices based on negotiations concluded in mid-February between Swedish iron ore producers and Ruhr steel producers as well as the British Steel Corporation were up by as much as 10 per cent. The Japanese market was quiet and was characterized by a few long-term contracts and some short-term purchases in the first half of the year that called for the same price for lump and fines as in 1970 but prices for pellets were higher.

Lake Erie base prices remained at 1971 levels while the Japanese and European markets for iron ore will be soft until the latter part of 1972 when the large iron ore inventory has been used up and the world steel industry, which was depressed at year-end, is expected to pick up. Little or no spot buying is expected in the Japanese market and prices established by long-term contract now in force will prevail although renegotiation of contracts with countries such as India can be expected because of the major realignment of currencies.

The Lake Erie base price increased for the second consecutive year in 1971. Prices for natural ore rose by as much as 52 cents a ton and for pellets by 1.4 cents an iron unit. However, these gains by the iron ore producer were offset somewhat by a general rise in lake freight rates and increased production costs, especially for labour and fuel oil. Lake freight rates rose by as much as 10 per cent during 1971, handling and dock charges from 7 per cent to 32 per cent, storage charges by 43 per cent, and for Welland Canal transit from $640/vessel to $800/vessel. The lake freight rate from head of Lake Superior to Ashtabula was therefore U.S. $2.25/long ton in 1971 compared to U.S. $2.05 the previous year. Lake Erie base prices from 1964 to 1972 are listed in Table 5.

It should be noted that price increases apply only to merchant ore but the higher transportation and production costs, which are said to be partly responsible for the upward trend, are also applicable for "captive" ores and thus, steel mills face higher iron ore costs regardless of ore source.

The price for Venezuelan iron ore entering the United States market is based on the Lake Erie base price of Mesabi Non-Bessemer ore according to agreements signed in 1964 between the concessionaires, United States Steel Corporation and Bethlehem Steel Corporation, and the Venezuelan Government. The

Table 5. Lake Erie base prices of selected ores, 1964-72

	1964-69	1970	1971-72
	($U.S. per long ton[1])		
Mesabi Non-Bessemer	10.55	10.80	11.17
Mesabi Bessemer (+ phos. premium)	10.70	10.95	11.32
Old Range Non-Bessemer	10.80	11.05	11.42
Old Range Bessemer	10.95	11.20	11.57
High Phosphorous	10.55	10.80	10.80
Pellets (per ton nat. unit[2])	0.252[3]	0.266	0.280

[1]51.5% of iron natural, at rail of vessel, lower lake port; coarse ore premium: 80¢ a ton and penalty for fines: 45¢ a ton. [2]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. [3]Price applicable for years from 1962 to 1969.

Table 6. Fob prices of Spanish iron ore imports, 1971

Country	Tons	Price[1]
		($U.S. per long ton)
Mauritania	309,000	10.19 to 10.33 (10.04 to 10.82)
Liberia	97,000	10.10 (9.60)
Canada	260,000 (pellets)	14.43 to 17.15 (14.52)
Brazil	36,000 (pellets)	13.37 (13.43)
	195,000 (lump)	9.10 to 9.74 (8.71 to 10.04)
Sweden	15,000 (pellets)	12.59 to 13.77 (13.09)
India	25,000	6.20
Angola	50,000	10.37

Source: *Metal Bulletin*, October 13, 1970, and August 3, 1971.
[1]1970 prices in brackets.

Table 7. Representative fob prices of Australian iron ore contracts, 1966-71

	Hamersley		Goldsworthy		Mt. Newman	
	Lump	Fines	Lump	Fines	Lump	Fines
	($U.S./dry long ton, 64% Fe basis)					
1966-67	9.92	7.68	9.86	7.25[1]	Nil	Nil
1968	9.37	7.68	9.37	7.68	9.37	7.13[1]
1969	9.37	7.63	9.37	7.68	–	–
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]

Source: *Japan Commerce Daily* and others,
– No record.
[1] 62% Fe.

fob price, Puerto Ordaz, for shipment to the United States was U.S. $8.22 a metric ton in 1970 compared with U.S. $7.94 a metric ton the year before owing to a rise in the reference price of U.S. $0.25 a long ton. With an increase of U.S. $0.52 a long ton in the reference price in 1971, the fob price, Puerto Ordaz, was an estimated U.S. $8.79 a metric ton.

Despite a depressed steel market at the beginning of 1971 Swedish iron ore prices for delivery to West Germany and Britain were up by as much as 10 per cent and Australian iron ore prices to European steel mills were up by 7.5 per cent as well. It was reported (*Japan Commerce Daily*, March 18, 1971) that the Carol Lake pellet price was U.S. 24.2¢ a dry long ton unit (65.3% Fe basis) fob Sept-Îles, an increase of 5 per cent or 1.1¢ a unit from 1970. Spain is increasingly becoming an important market for world iron ores and, as shown in Table 6, fob prices in this market were up from 1970 for most iron ores.

Generally, Europe's steel producers, unlike those in the United States and Japan have relatively unprotected forward positions in that about half of their ore is obtained by annual contracts, usually in the preceding December. However, they departed from this practice in 1970 by signing for periods of more than a year and therefore, many 1970 prices were applicable for 1971.

The mid-1970 fob price for Kiruna D ore (60 per cent Fe, 1.8 per cent P) was U.S. $8.03 a long ton (*Annales des Mines*: 40.75 krona/metric ton) up from U.S. $7.09 a long ton (Chambre Syndicale des Mines de Fer de France: 36 krona/metric ton) in 1969. Also, Grangesberg lump No. 1 was U.S. $8.46 a long ton (43 krona/metric ton) compared to U.S. $7.39 a long ton (37.5 krona/metric ton) the year before (Chambre Syndicale des Mines de Fer de France). Swedish pellet prices were also up, and they ranged in mid-1970 from U.S. $12.25 to U.S. $12.80 a ton (60% Fe dry basis).

The Price for Kiruna D ore (60 per cent Fe, 1.8 per cent P) cif Rotterdam, which is indicative of the European market, was U.S. $9.33 a metric ton (15.7¢ a long ton unit) in 1970 compared to U.S. $8.37 in 1969. The increase reflected not only higher fob prices but increased shipping rates as well, which rose from U.S. $1.21 a metric ton to U.S. $1.28. The mid-1970 Rotterdam price for Malmberget pellets was an estimated 23.0¢ a long ton iron unit and for Kiruna-Svappaara pellets, 23.9¢ a long ton iron unit.

The cif prices Rotterdam for the various Liberian Lamco ores are also good indicators of the European market. In 1970, the posted fob price a metric ton (60 per cent Fe) was U.S. $8.40 (U.S. $7.20 in 1969) for Nimba washed lumpy, U.S. $7.20 (U.S. $6.00) for Nimba washed fines, and U.S. $12.50 (U.S. $10.65) for Nimba pellets. Taking into account a freight rate of U.S. $3.00 (U.S. $2.70 in 1969), estimated cif prices for wash lumpy, washed fines and pellets were 18.7¢, 16.6¢ and 25.5¢ a long ton iron unit.

The mid-1970 fob mine price, 32-per-cent-iron base, for French ore was 13.3 francs (*Annales des Mines*; equivalent to about U.S. $2.45 a ton) compared with 12.58 francs in the fourth quarter of 1969, 11.57 francs in the first quarter of 1969, 11.86 francs in 1968 and 12.66 francs in 1967.

Voyage charter rates for smaller and older vessels were reported to be down from 1970 because of the market reductions in the world volume of trade. On the other hand, voyage charter rates for the larger vessels, say greater than 30,000 tons, were up by as much as 25 per cent to reflect the upward revaluation of most world currencies, such as the yen and the mark vis-à-vis the United States dollar, in the latter half of the year. The realignment of world currencies is expected to maintain shipping rates in terms of United States dollars at high levels in 1972; shipbuilding costs are expected to be up as well.

The excess stocks situation and the bleak outlook for steel production until at least mid-1972 are expected to have a downward effect on prices in 1972 for those sellers with no contracts or those with contracts for fixed tonnage but not prices. It was reported (*Metal Bulletin*, November 26, 1971) that the annual negotiations between the Swedish iron ore producers and European steel producers on new iron ore contracts due to take place in late 1971 was postponed until 1972. This was attributed to the state of the steel market and the world monetary situation.

The Japanese market was quiet in 1971 and was characterized by a few long-term contracts and some short-term purchases in the first half of the year as well as negotiation of contract renewals that sometimes saw buyer and seller wide apart on terms. As Table 7 shows, Australian prices in 1971 for short-term contracts were U.S. $9.58 for lump, the same as in 1970, and U.S. $7.25 for fines, up slightly from the previous year. The cif price for Australian ores, which sets the pattern for prices of other ores entering the Japanese market because of their high grade, high quality and closeness to Japan, were therefore about U.S. $11.58 and $9.25 for lump and fines taking into account an estimated shipping cost of $2 a ton. A contract with Cia. Acero del Pacifico of Chile for 36-42 million tons over a 12-year period starting in 1972, called for fob prices from U.S. $7.50 to $7.80 a ton for lump (62% Fe) and from U.S. $5.45 to $5.90 for fines (62% Fe). Shipping rates are about $3.65 a ton.

An extension of a two-year pellet contract with Marcona of Peru called for a c & f price of 26.5 cents an iron unit on a dry basis equivalent to 20.0 cents fob with a shipping cost of 6.5 cents an iron unit. This is up from the 22.1 cents to 24.5 cents c & f an iron unit called for in previous pellet contracts covering some 18 million tons. In a fifth long-term trade agreement with Cia. Vale do Rio Doce of Brazil signed in 1971, a standard price of 20 cents an iron unit fob was set. The Japanese steelmaking industry estimates a standard import price for overseas iron ore pellets at 19.5 to 20 cents fob per Fe unit. The new Marcona c & f pellet price is quite significant in that it is likely to serve as a guidepost in future negotiations involving importation of pellets to Japan. However, this price appears rather low for the North American producer who faces higher production and shipping costs.

Two contracts of Iron Ore Company of Canada both call for a price of U.S. 16.4¢/DLT unit on a special c & f basis with freight rates U.S. $3.775 for one contract (using 165,000-ton vessels) and U.S. $3.155 for the other (using 250,000-ton vessels). A Quebec Cartier Mining contract for six million tons (1.2 million tons for five years) calls for a price of U.S. 16.5¢/DLT unit. The low freight rates for 15,200 miles are made possible by the transportation in large oil-bulk-ore (OBO) carriers that can backhaul oil from Kuwait. Texada Mines Ltd. receives U.S. $11.62 c & f a dry metric ton for its concentrate and Wesfrob Mines Limited U.S. $9.12 fob a dry metric ton for its sinter feed and U.S. $9.07 fob a dry metric ton for its pellet feed.

The balanced supply-demand relationship that may exist in the Japanese market to 1975 and the possibility of increased sales by Australian iron ore producers in other markets may have a stabilizing effect on iron ore prices to 1975. Delivered (cif) prices are expected to rise to cover higher shipping costs despite increasing economics of scale in production and transportation; there may be a reduction in fob prices to competitive markets to compensate for higher transportation cost from many sources of good-quality iron ore.

To offset rising prices it is expected that more stringent chemical and physical specifications with higher penalties will be written into future Japanese contracts. Also, refusal of shipments can be expected especially if sulphur and phosphorus do not meet specifications. New specifications for such physical properties that attempt to ascertain an ore's performance in the blast furnace, such as reducibility and swelling, may be parameters of price in future contract negotiations. Low-sulphur ores will be in greater demand because of the ever-increasing controls on air pollution. There may be a shift from sinter to pellet despite the fact that sinter costs about 3 cents an iron unit less to the blast furnace than pellets; sinter and pellets are reported to perform equally well in blast furnace productivity. Sinter plants are usually great sources of air pollution whereas pellets have negligible sulphur content.

Outlook and forecast

The growth of the Canadian iron ore industry is primarily dependent upon the growth in exports because about 80 per cent of production is now exported and domestic demand will increase only moderately. Therefore to properly assess the role that Canadian iron ores will play in world markets of the future, one must assess the iron ore demand-supply patterns of the world's major steel-producing countries and the role that both domestic and imported ore will have in them.

Canada's raw steel production in 1972 may set a new record approaching 12.8 million net tons if there are no interruptions because of strikes; it would be up sharply from the 12.2 million net tons produced in 1971 and surpass the record of 12.3 million net tons in 1970. The sharp increase forecast appears to be reasonable since, despite a slight decline in steel production in 1971 from the previous year, indicated raw steel consumption was up by 1.0 million net tons to 13.2 million net tons. Exports of steel were at 1970 levels but imports were up by an estimated 1.0 million net tons to 3.2 million net tons to more than take up the loss in steel production which declined mainly because of blast furnace problems. An increase in Canadian pig iron and crude steel capacities in 1972, and the upward revaluation of most world currencies vis-à-vis the Canadian dollar should result in some import reductions. The lifting of the United States import surcharge augurs well for Canadian steel exports to that market and, with domestic demand for capital and consumer goods remaining high, record steel production in 1972 is anticipated. A possible labour strike in mid-1972 as the current three-year agreement expires could prevent these expectations for 1972 from being realized.

To parallel the rise in steel production, domestic iron ore consumption is forecast to 11.7 million tons, up 0.9 million tons from 1971. Imports are anticipated to remain at the 1971 level of 1.4 million tons but because of 0.4 million tons of excess iron ore stocks at steel plants at year-end domestic shipments are expected to be up by only 0.3 million tons to 10.0 million tons.

The situation for iron ore exports appears to be mixed for 1972. Most countries expect their steel industries to continue producing at 1971 rates throughout most of 1972 with recovery anticipated only in the latter part of the year. The outlook for United States steel production appears good and an increase of 11 million net tons to the level produced in 1970 appears reasonable. However, the excess iron ore stocks situation and the possible slow recovery in steel production in Japan and western Europe, Canada's two other major markets, are expected to affect exports to those markets downward by at least 10 per cent. Therefore, total iron ore exports are forecast up by 1.5 million tons to 34.9 million tons comprised of 22.8 million tons to the United States, 9.4 million tons to western Europe and 2.7 million tons to Japan.

Iron ore shipments in 1972 are forecast to 44.9 million tons comprised of 34.9 million tons of exports and 10.0 million tons of domestic shipments. Production will exceed shipments by about 1.0 million tons and stocks at mines and ports, estimated to contain 10.4 million tons at the end of 1971 will go up accordingly.

Iron ore shipments in 1975 are expected to reach 65 million tons comprised of 53.4 million tons of exports and 11.6 million tons of domestic shipments. The export estimate will be realized if Canada increases its share of the market in the United States, Britain and western Europe and begins major shipments to Japan from new or expanded facilities in Quebec and Labrador. Iron ore plants under construction or planned as of 1971 will add some 34.67 million tons of production capacity by 1976. On the negative side, annual production capacity is expected to decrease at several mines. New requirements for domestic consumption by 1975 could well be met by developments in several areas of which the most important might be expansion of Wabush Mines, which is 42 per cent owned by Stelco and Dofasco.

Annual shipments totalling 90 million tons comprised of 74 million tons of exports and 16 million tons of domestic shipments are anticipated for 1980. The estimate for exports may appear high but the 74 million tons as a share of the total potential world market, or 15 per cent, is only slightly above the estimated 13 per cent recorded in 1970 when Canadian exports reached their peak. The principal factors that could account for this growth include the inability of new and traditional world sources to meet the increasing demand for beneficiated high-grade ore, the proximity of Canada's large beneficiating-grade iron ore deposits to the United States and Europe, the existence of deepwater ports on the St. Lawrence River to enable concentrates and pellets to compete in major markets, particularly Japan, the existence of mine infrastructure that facilitates expansion or new building, and continuing favourable political and fiscal policies. The United States will continue to be the largest market with 32 million tons, followed by Japan with 20 million tons, the ECSC with 13 million tons and Britain with 9 million tons; the domestic market should absorb about 16.4 million tons. It is expected that total annual capacity will be about 105 million tons by the end of 1980.

Iron and Steel

V.B. SCHNEIDER

Crude* steel production in Canada amounted to 12.17 million tons** in 1971, including 205,320 tons of steel castings, down some 176,580 tons from the all-time high of 12.35 million tons in 1970. The tonnage and value of steel imports again exceeded exports. Only during 1968 and 1970 have steel exports exceeded imports both in tonnage and in value. Some of the increase in imports was attributable to the start of a buildup in inventories late in 1971 in anticipation of increased demand in 1972, foreign revaluation of currencies, and as a hedge against possible disruptions during labour negotiations scheduled for mid-1972. The value of imports of steel castings, ingots and rolled products amounted to $423 million, compared with $362 million for 1970. Exports in 1971 amounted to $312 million, down $35 million from 1970. Minor blast furnace difficulties experienced by three major producers were the main reason why production in 1971 did not exceed that for 1970. However, the correction of these problems and some additional 1.5 million tons of new steel capacity should reduce imports in 1972.

Apparent domestic consumption of steel products at 13.2 million tons, on a crude steel basis, was at an all-time high. Apparent consumption calculations do not take into account inventory changes; therefore real consumption, on a crude steel basis, was probably slightly less than 13 million tons. Converted to salable steel products this amounted to some 9.8 million tons.

Steel prices continued to rise for a variety of products in most steelmaking countries in 1971. notwithstanding an over-all decline in demand. Canadian prices for selected hot-rolled and cold-rolled products rose 4.8 per cent. Prices in Europe rose during the first half of the year but gradually declined during the second half; however, not all of the earlier price increases were eroded. Price increases in the United States varied from 6 to 8 per cent and came under the regulation of the Federal Price Commission. In Japan, the export price of steel to the United States was increased from $10 to $12 a ton at midyear but after the revaluation of the yen the increases were adjusted downwards.

Although most Canadian steel companies enjoyed record sales, profits were generally lower than in 1970. The decline in profits was not always entirely attributable to reduced profit margins on finished products. The ending of the three-year income tax period on iron ore mining operations was a contributory factor for two of the major steel companies. The aggregate of the three largest producers, who account for about 78 per cent of Canadian production shows that profits as a percentage of sales were 7.8 per cent in 1971 compared with 9.3 per cent in 1970.

The Steel Committee of the Economic Commission for Europe (United Nations) held its thirty-ninth session in October 1971. This body conducts studies and publishes reports on all phases of the world's steel industry. Current projects include: Production and Use of Steel Tubes; Long-term Prospects for Steel Production, Consumption and Trade; and Distribution and Marketing of Steel Products. In 1971, the Committee conducted a seminar on Air and Water Pollution in the Iron and Steel Industry with the U.S.S.R. as the host country. In September 1972 the Committee will conduct a seminar on the Process of Direct Reduction, with Romania as the host.

*Crude steel includes ingots, continuous cast sections, and steel castings. **The net ton of 2,000 pounds is used throughout, unless otherwise indicated.

World production

Steel production declined in most countries in 1971, with total production reaching an estimated 638 million tons compared with 655 million tons in 1970. The U.S.S.R. was a notable exception, as production in 1971 increased by some 4 per cent. The United States and Japan posted the largest decreases with U.S. output being down almost 9 per cent and Japan's about 5 per cent. The outlook for 1972 is cautiously optimistic but most countries expect their steel industries to continue producing below capacity throughout most of the year. An upturn in world demand is expected late in 1972 and this should be reflected by increased production in 1973. The United

Table 1. Canada, general statistics of the domestic primary iron and steel industry, 1969-71

	1969	1970	1971p
Production			
Volume indexes			
Total industrial production, 1961=100	168.7	172.3	177.6
Iron and steel mills,[1] 1961=100	159.3	176.8	180.4
	($ millions)	($ millions)	($ millions)
Value of shipments, iron and steel mills[1]	1,415.6	1,684.2	1,746.7
Value of unfilled orders, year-end, iron and steel mills[1]	225.0r	182.5	238.1
Value of inventory owned, year-end, iron and steel mills[1]	299.4r	359.2	370.7
Employment, iron and steel mills[1]	(number)	(number)	(number)
Administrative	8,513r	10,852	9,463
Hourly rated	34,441r	38,317	37,752
Total	42,954r	49,169	47,215
Employment index, all employees, 1961=100	126.1	137.6	136.9
Average hours per week hourly rated	40.1	40.2	39.9
	($)	($)	($)
Average earnings per week, hourly rated	139.81	155.42	169.55
Average salaries and wages per week, all employees	147.94	163.82	173.00
Expenditures, iron and steel mills[1]			
Capital	($ millions)	($ millions)	($ millions)
on construction	15.9	39.7	27.7
on machinery	92.5	168.2	159.0
Total	108.4	207.9	186.7
Repair			
on construction	9.2	10.5	11.8
on machinery	132.0	168.1	184.0
Total	141.2	178.6	195.8
Total capital and repair	249.6	386.5	382.5
Trade, primary iron and steel[2]			
Exports	267.8	382.4	345.2
Imports[3]	410.4	362.0	423.5

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 – compilation by Mineral Resources Branch. [3]There were negligible imports of pig iron in 1970 and 1971.
pPreliminary; rRevised.

States, Canada and most of the communist bloc countries expect significant production increases in 1972 from 1971. Little change in production has been forecast for western Europe in 1972 with anticipated small increases for Italy, France and Spain being offset by decreases in other countries, especially West Germany.

Some of the major Japanese steel companies were planning to drastically reduce new capital outlays until 1975 and beyond, to avoid excess production capacity in the steel industry. Present capacity plus facilities already under construction are considered sufficient to meet steel requirements to 1975, which are now expected to range from 132 to 143 million tons a year. Earlier forecasts had predicted requirements in the order of 165 million tons of steel ingots a year.

Canadian primary iron and steel industry*

Pig iron is made at seven plant locations in Canada and raw steel is made at eighteen. Four of these are integrated and produce both pig iron and steel. There are also three plants that have rolling mills but no iron or steel furnaces. The four integrated plants – two at Hamilton, Ontario, and one each at Sault Ste. Marie, Ontario and Sydney, Nova Scotia – accounted for about 85 per cent of crude steel production and about 90 per cent of the pig iron production in 1971.

Pig iron. Production of pig iron declined 6 per cent in 1971 to 8.6 million tons. Production was adversely affected in 1971 by minor blast furnace problems at three plants. These problems, however, were all rectified by year-end and the total number of blast furnaces in operation was increased by the start-up of a new furnace in March 1971 by Dominion Foundries and Steel, Limited (Dofasco). Slight modifications and improvements at other plants increased Canadian pig iron production capacity in 1971 from 9.9 million tons to 11.2 million tons a year.

Crude steel. Production of crude steel in 1971 at 12.17 million tons was down slightly from the record of 1970 but was the second highest ever. Production of steel castings rose some 7 per cent to an all-time high of 205,320 tons. Open-hearth furnaces produced 52 per cent of total crude steel, oxygen furnaces produced 33 per cent and electric furnaces accounted for 15 per cent of the total in 1971. Production from both basic oxygen and electric furnaces, especially the former, will be replacing that from open hearths. Indicated steel consumption at 13.2 million tons of ingot equivalent increased some 8 per cent in 1971 from 12.2 million tons in 1970 and established an all-time high.

Total crude steel production capacity in Canada was 15.46 million tons at the end of 1971 and

*A complete listing of Canadian primary iron and steel plants including steel foundries is in the booklet "Operators List 1, Part 1: Primary Iron and Steel" (75 cents). More detailed statistics are compiled in MR 113, "Canadian Primary Iron and Steel Statistics to 1969" (75 cents). Both are available from Mineral Resources Branch or Information Canada.

Table 2. World production of crude steel, 1969-71

	1969[r]	1970[r]	1971[p]
	(thousands of net tons)		
North America, total	155,132	148,138	136,636
Canada	10,048	12,346	12,170
Mexico	3,822	4,278	4,255
United States	141,262	131,514	120,211
South America, total	9,453	10,088	11,169
Western Europe, total	170,487	176,301	164,973
Belgium and Luxembourg	20,232	19,918	19,497
France	24,814	26,205	25,198
West Germany	49,951	49,649	44,437
Italy	18,109	19,045	19,238
Netherlands	5,195	5,545	5,589
Total ECSC	118,301	120,362	113,959
Britain	29,594	31,212	26,646
Other	22,232	24,727	24,368
Eastern Europe, total	164,814	174,002	181,032
Czechoslovakia	11,926	12,655	13,117
Poland	12,446	13,001	13,724
U.S.S.R.	121,570	127,717	132,277
Other	18,872	20,629	21,914
Africa and Middle East, total	5,720	5,938	6,068
Far East, total	118,147	132,691	130,679
China	17,637	19,842	23,149
India	7,132	6,967	6,692
Japan	90,572	102,870	97,617
Other	2,806	3,012	3,221
Australia and other Oceanian	7,733	7,520	7,518
World total	631,486	654,678	638,075

Sources: Canada: Statistics Canada. United States: Annual Statistical Report, American Iron and Steel Institute, and for 1971, Survey of Current Business, May 1972. Japan: Annual Report, Japan Iron and Steel Federation. European Common Market countries: Statistisches Bundesamt, Düsseldorf; Bulletin de la Chambre Syndicale de la Siderurgie Française, December 1971. Other western European: Statistisches Bundesamt, Düsseldorf; Metal Bulletin, May 1972. Eastern European countries: Bulletin de la Chambre Syndicale de la Siderurgie Française, December 1971. Other Far Eastern: Statistisches Bundesamt, Düsseldorf; Metal Bulletin, May 1972.
[p]Preliminary; [r]Revised.

Table 3. Canada, pig iron production, shipments, trade and consumption, 1969-71

	1969	1970	1971p
	(net tons)		
Furance capacity, December 31			
Blast	9,005,000	10,625,000	10,125,000[1]
Electric	575,000	710,000	782,000
Total	9,580,000	11,335,000	10,907,000
Production			
Basic iron	6,538,148r	8,275,191	7,835,632
Foundry iron	616,301r	810,764	780,124
Malleable iron	276,238r	*	*
Total	7,430,687r	9,085,955	8,615,756
Shipments			
Basic iron	39,309r	51,511	47,883
Foundry iron	618,509r	803,637	709,545
Malleable iron	213,312r	*	*
Total	871,130r	855,148	757,428
Imports			
Net tons	22,944	96	670
Value ($000)	1,104	9	39
Exports			
Net tons	721,644	642,797	549,454
Value ($000)	35,815	35,320	32,767
Consumption of pig iron			
Steel furnaces	6,296,304	8,063,315	7,676,289
Iron foundries	282,591	289,939	279,384
Consumption of iron and steel scrap			
Steel furnaces	5,134,762	5,940,659	6,226,859
Iron foundries	1,063,769	869,441	1,070,664

Source: Statistics Canada, Primary Iron and Steel (monthly); Iron and Steel Mills (annual) and Iron Castings and Cast Iron Pipe and Fittings (monthly).
*Included under "Foundry iron". [1]Does not include one furnace under repair and one held only for standby capacity.
pPreliminary; rRevised.

investment projects under way or planned will raise annual capacity to 15.55 million tons by late 1972.

Steel pipe and tube. The Canadian steel pipe and tube industry had an annual capacity of 2,831,000 tons at the end of 1971, an increase of 217,000 tons from 1970. Capacity has been rising rapidly since the mid-1950's when steel pipe and tube capacity was 414,000 tons a year and centred entirely in Quebec and Ontario. Developments since then have resulted in one half of the domestic capacity being installed in western Canada to serve, primarily, the petroleum and natural gas industries.

Steel pipe and tube production established a new record in 1971 of 1,102,873 tons, up 3.5 per cent from the near-record level of 1970. Big-inch pipeline (20-inch diameter and larger) construction totalled 680 miles in 1971. Projections for 1972 indicate construction of nearly 1,200 miles of big-inch pipeline. The total of big-inch and little-inch construction in 1972 is expected to exceed 7,000 miles.

The Steel Company of Canada, Limited (Stelco) is the largest manufacturer of steel pipe and tube in Canada. Page-Hersey Tubes Limited and Stelco formed Welland Tubes Limited as a joint venture in 1955. Camrose Tubes Limited was similarly incorporated in 1959. Stelco acquired Page-Hersey in 1964 and, consequently, full ownership of Welland Tubes and Camrose Tubes. In addition, the extensive wholly owned Page-Hersey pipe- and tube-making plants at Welland, Ontario and Camrose, Alberta were acquired by Stelco. Stelco operates 13 pipe and tube mills at five locations and accounts for over 40 per cent of domestic capacity.

Table 4. Canada, crude steel production, shipments, trade and consumption, 1969-71

	1969	1970	1971p
	(net tons)		
Furnace capacity, December 31			
Steel ingot			
Basic open hearth	6,970,000	6,970,000	5,380,000
Basic oxygen converter	3,800,000	4,400,000	6,690,000
Electric	2,055,450	2,294,450	2,961,600
Total	12,825,450	13,664,450	15,031,600
Steel casting	415,925	418,925	429,525
Total furnace capacity	13,241,375	14,083,375	15,461,125
Production			
Steel ingot			
Basic open hearth	5,031,804r	6,906,491	6,330,838
Basic oxygen	3,509,038	3,617,985	3,934,965
Electric	1,353,772r	1,629,935	1,698,429
Total	9,894,614r	12,154,412	11,964,232
Continuously cast in total	1,212,813	1,398,463	1,393,724
Steel castings[1]	152,943r	191,720	205,320
Total steel production	10,047,557r	12,346,132	12,169,552
Alloy steel in total	838,488r	1,098,546	1,094,362
Shipments from plants			
Steel ingots	472,377	507,413	496,379
Steel castings	153,959	181,952	200,037
Rolled steel products	7,984,841	9,084,605	9,220,748
Total	8,611,177	9,773,970	9,917,164
Exports[2], equivalent steel ingots	1,423,352	2,299,201	2,130,320
Imports[2], equivalent steel ingots	2,934,414	2,189,320	3,136,105
Indicated consumption, equivalent steel ingots	11,558,619	12,236,251	13,175,337

Source: Statistics Canada.
[1]Includes basic open hearth and electric. [2]Computed by Mineral Resources Branch.
rRevised; pPreliminary.

Canada's second largest producer is Canadian Phoenix Steel & Pipe Ltd. with plants at Toronto, Edmonton, Calgary and Port Moody, British Columbia.

In 1971, The Algoma Steel Corporation, Limited leased the Mannesman Tube Company, Ltd's seamless pipe and tube plant at Sault Ste. Marie, Ontario for a period of 15 years. Algoma will have an option to purchase the plant from the sixth year of the lease. This adds oil well casing, transmission line pipe, standard pipe and mechanical tubing to Algoma's range of steel products.

A new concept in Canadian pipemaking was introduced in 1971 with the establishment of International Portable Pipe Mills Ltd. in Calgary. The plant is entirely self-contained and can be moved distances of from 200 to 500 miles in about a month.

Outlook and forecast

The Canadian economy more than met expectations in 1971 in terms of the rate of growth of production. As the economic expansion developed, private sector spending for consumer durables and housing assumed the dynamic role in providing a stimulus to the economy. Capital . expenditures in the resource industries were high but in manufacturing they were disappointing. The review by Statistic Canada* indicated that total capital expenditures by all sectors were in the order of $19,788 million. This represents an increase of 11 per cent from the $17,798 million outlay for new construction and machinery in 1970 and, as might be expected, steel demands were high.

**Private and Public Investment in Canada, Outlook 1972, and Regional Estimates,* Statistics Canada, Catalogue No. 61-206 Annual.

Table 5. Canada, production, trade and apparent consumption of crude steel, 1962-71

	Crude Steel Production	Imports[1]	Exports[1]	Indicated Consumption[2]
	('000 net tons equivalent ingots)			
1962	7,173	1,046	990	7,229
1963	8,190	1,295	1,369	8,116
1964	9,128	2,135	1,485	9,778
1965	10,068	2,892	1,235	11,725
1966	10,020	2,096	1,290	10,826
1967	9,701	1,981	1,368	10,314
1968	11,198	1,884	2,079	11,003
1969	10,048^r	2,934	1,423	11,559^r
1970	12,346	2,189	2,299	12,236
1971^p	12,170	3,136	2,130	13,176

Source: Statistics Canada.
[1]From Trade of Canada, adjusted to equivalent crude steel by Mineral Resources Branch. [2]Production plus imports, less exports with no account taken for stocks.
^{p}Preliminary; ^{r}Revised.

Prospects for the Canadian steel industry for 1972 are good with crude steel production expected to exceed 12.5 million tons and approach 13 million tons. On this basis, shipments of finished products from the mills will probably be between 9.8 million tons and 10.1 million tons. Export possibilities are not favourable, as most consumer countries will have excess production capacity and imports, particularly from Japan and western Europe, will continue to harass the domestic industry. The western Canadian market is particularly accessible to offshore skelp for line pipe and many construction materials.

For 1972, Statistics Canada's review forecasts a rather modest increase of 6 per cent in capital expenditures over those of 1971. However, it is significant that predicted expenditures by oil and gas companies, transportation and communications companies and real estate developers are well above 1970 levels. Therefore, economic forecasts of activities support the prediction that demand for steel products in 1972 will reach an all-time high. The one discouraging note is that the manufacturing sector of the economy continues to indicate a declining rate of capital expenditures on new plants and equipment.

Table 6. Canada, net shipments of rolled steel products by type, 1969-71

	1969	1970	1971^p
		(net tons)	
Hot-rolled products			
Semis	379,300	503,817	448,723
Rails	308,266	353,225	297,618
Wire rods	464,745	568,569	611,396
Structurals			
Heavy	464,641	618,858	557,592
Light	139,906	137,293	144,220
Bars, concentrate reinforcing	699,910	730,755	755,645
Bars, other hot-rolled	744,536	807,834	799,877
Tie plate and track material	84,555	91,765	83,765
Sheet and strip	1,544,156	1,717,006	1,871,037
Plates	967,794	1,255,400	1,174,222
Total	5,797,809	6,784,522	6,744,095
Cold-rolled products			
Bars	81,831	67,391	68,799
Sheet, tin mill blackplate and tinplate	1,499,340	1,602,132	1,698,388
Galvanized sheet	605,861	630,560	709,466
Total	2,187,032	2,300,083	2,476,653
Total shipments	7,984,841	9,084,605	9,220,748
Alloy steel in total shipments	422,414	561,336	525,425

Source: Statistics Canada, Primary Iron and Steel (monthly).
^{p}Preliminary.

Table 7. Canada, net shipments of rolled steel products (carbon and alloy) to consuming industries, 1969-71

	1969	1970	1971p
		(net tons)	
Automotive and aircraft	847,669	855,793	1,105,710
Agricultural equipment manufacturers	155,105	140,565	134,509
Construction	1,464,012	1,577,876	1,514,133
Containers	497,979	515,604	529,845
Machinery and tools	287,589	297,963	300,751
Wire, wire products and fasteners	536,259	559,735	584,263
Resources and extraction	163,910	210,295	194,638
Appliances, utensils, stamping, pressing	603,212	591,053	693,428
Railway operating	325,991	405,677	331,591
Railway cars and locomotives	95,281	124,080	108,336
Shipbuilding	49,916	59,544	52,906
Pipes and tubes	947,116	1,121,276	1,161,746
Wholesalers and warehouses	1,146,923	1,232,869	1,229,124
Miscellaneous	86,874	64,581	61,604
Total	7,207,836	7,756,911	8,002,584
Direct exports[1]	777,005	1,327,694	1,218,164
Total	7,984,841	9,084,605	9,220,748

Source: Statistics Canada, Primary Iron and Steel (monthly).
[1]Does not include exports by nonproducers, nor ingots and castings.
pPreliminary.

The steel industry, including iron and steel mills, steel pipe and tube mills and iron foundries, forecasts expenditures in 1972 of $431 million for new plants and equipment, and for repairs to existing plants and equipment. This will be an all-time high.

The Canadian steel industry must negotiate a new labour contract in 1972 as the current three-year agreement expires on July 31 and it is possible that this process will prevent the current expectations for 1972 from being realized. Prospects for the mid- to long term remain optimistic and a concensus of informed persons continues to suggest that by 1975 and 1980 domestic production capacity must reach 17.8 and 24 million tons in terms of crude steel equivalent to meet domestic requirements.

Trade

Canada again failed to achieve a favourable balance of trade in primary steel products and in castings, forgings, pipe and wire in 1971. However, in recent years the degree of self-sufficiency in primary steel products has improved considerably. During the post-World War II years many imports were dictated by economies of scale that discouraged Canadian production of some primary steel products. The growth rate in the demand for steel was extremely high in Canada during the past decade. The Canadian steel industry is technologically advanced and has been quick to modernize so that now there are very few steel products that must be imported because the Canadian industry lacks the facilities or capacity to produce them domestically. Three things mitigate against a rapid decline in steel imports in the midterm of five to ten years: Canadian geography, with high transportation costs to some areas from steel production centres; higher costs for some items by Canadian producers because of relatively short runs on expensive mills; and the importation of products not yet made in Canada because of size of market.

The rate of imports into Canada increased rapidly towards the end of 1971, probably in anticipation of a work slowdown during labour-industry contract talks in mid-1972 and of increased demand for skelp for the oil and gas pipeline programs in western Canada. There was also a 125 per cent increase in imports from Japan over those of 1970, mostly into the western Canadian market.

Steel imports exceeded exports by some 0.7 million tons, or $111 million. By products, imports exceeded exports for hot-rolled items such as semis, wire rods, structurals, plate and sheet and strip; and for cold-rolled items such as sheet and strip, pipe and wire. Exports were higher than imports for such cold-rolled products as galvanized sheet and strip and stainless sheet and strip, and for such hot-rolled products as steel castings and ingots, rails and other track materials.

Table 8. Canada, trade in steel castings, ingots and rolled products, 1969-71

	Imports			Exports		
	1969	1970	1971p	1969	1970	1971p
	('000 net tons)					
Steel castings	7.8	8.8	7.0	28.9	29.1	31.6
Steel forgings	11.1	10.7	12.0	37.8	34.0	16.9
Steel ingots	23.0	44.0	38.9	80.2	76.5	78.6
Hot-rolled products						
Semis	278.2	206.5	238.0	91.6	89.4	123.2
Rails	6.2	7.6	12.9	57.7	81.9	65.8
Wire rods	225.0	161.2	204.2	54.1	127.0	135.8
Structurals	395.9	292.9	306.2	77.9	139.7	148.6
Bars	236.7	110.0	166.1	75.4	176.1	72.4
Track material	3.2	4.2	2.7	3.5	3.5	4.7
Plates	282.4	193.3	278.9	52.9	122.8	164.0
Sheet and strip	201.4	145.9	401.9	89.7	200.1	196.1
Total hot-rolled	1,629.0	1,121.6	1,610.9	502.8	940.5	910.6
Cold-rolled and other products						
Bars	20.0	16.2	14.9	11.6	14.2	11.3
Sheet and strip cold-rolled	71.0	40.1	172.7	86.9	191.1	151.4
Galvanized	16.5	17.4	48.4	74.3	90.4	112.3
Other[1]	133.8	104.9	99.4	109.4	142.3	135.2
Pipe	209.5	207.6	274.4	170.5	236.4	180.1
Wire	92.7	76.6	76.3	15.3	18.7	28.1
Total cold-rolled and other	543.5	462.8	686.1	468.0	693.1	618.4
Total rolled products	2,172.5	1,584.4	2,297.0	970.8	1,633.6	1,529.0
Total steel	2,214.4	1,647.9	2,354.9	1,117.7	1,773.2	1,656.1

Source: Statistics Canada, Trade of Canada; compilation by Mineral Resources Branch.
[1]Includes hot-rolled stainless sheet and strip.
pPreliminary.

Table 9. Canada, value of trade in steel castings, ingots and rolled products, 1969-71[1]

	Imports			Exports		
	1969	1970	1971p	1969	1970	1971p
	($ thousands)					
Steel castings	7,106	6,967	5,526	11,471	11,836	11,009
Steel forgings	11,020	11,899	12,042	19,758	18,910	9,660
Steel ingots	1,806	3,594	3,294	9,411	8,240	7,724
Rolled products						
Hot-rolled	211,944	176,812	214,007	83,655	149,980	142,433
Cold-rolled and other	177,399	162,692	188,597	107,681	158,142	141,567
Total rolled	389,343	339,504	402,604	191,336	308,122	284,000
Total steel	409,275	361,964	423,466	231,976	347,108	312,393

Source: Statistics Canada, Trade of Canada.
[1]The values in this table relate to the tonnages shown in Table 8.
pPreliminary.

Table 10. Canada, trade in steel by country, 1969-71[1]

	Imports From			Exports To		
	1969	1970	1971p	1969	1970	1971p
	(thousand net tons)					
United States	1,019.1	799.7	785.2	869.6	1,222.5	1,294.0
Britain	162.9	143.4	164.0	41.8	80.2	43.5
ECSC[2] countries	418.6	194.2	364.2	16.6	84.2	41.7
Other European[3]	173.7	107.9	146.4	15.7	109.1	12.2
Africa	2.7	0.9	0.2	4.6	10.5	7.2
Japan	404.6	391.3	886.4	11.3	0.3	0.5
Other Asian	0.9	2.3	2.1	9.6	27.1	44.0
Latin America	–	0.2	–	121.1	190.8	172.7
Middle East	–	–	–	9.8	10.1	15.4
Oceania	31.9	8.0	6.4	17.6	38.4	25.0
Total	2,214.4	1,647.9	2,354.9	1,117.7	1,773.2	1,656.2

Source: Statistics Canada, Trade of Canada; compilation by Mineral Resources Branch.
[1]Products included are those listed in Table 8. [2]European Coal and Steel Community (ECSC). [3]Includes the U.S.S.R.
pPreliminary; – Nil.

The United States continued to be Canada's most important customer for steel products, followed by Latin America, Britain, the European Coal and Steel Community (ECSC) countries and Oceania. Exports to the U.S.A. increased in 1971 from 1970 but for most other countries they decreased with the most notable exception being the Asian trade other than to Japan, which increased 63 per cent but from a very small base. The biggest decreases in exports in 1971 from the previous year were to Britain and other European countries where exports dropped from 273,500 tons in 1970 to 97,400 tons in 1971.

Japan replaced the United States as the major supplier of imports in 1971. The greatest imbalance between imports and exports occurred in Canadian trade with Japan where imports in 1971 amounted to 886,400 tons compared with exports of 500 tons. The United States was closely behind Japan as a supplier of imports, but the balance in trade favoured Canada by some 509,000 tons, followed by the ECSC countries, Britain and other European countries outside the ECSC group.

Raw materials

Consumption of raw materials in the manufacture of steel remained about the same as in 1971 as suggested by the high level of production. However, costs for both iron ore and coking coal increased about 5 per cent. Higher-quality steel products, to meet the higher standards and specifications of today's advanced technology, have resulted in increased consumption of ferroalloys and other additives that are used by the steel industry. After several years of increasing prices, the price for ferroalloys and other additives levelled off in 1971 and in some cases even decreased in a buyer's market.

Steel scrap was in adequate supply in most Canadian consuming areas and with a decrease in demands for exports the price remained reasonably stable throughout 1971. In southern Ontario, the cost of No. 1 heavy melting ranged from $30 to $38 a ton, reaching a high of $38 a ton in midsummer from a low of $30 a ton in March and April. By year's end the price was about $31 a ton and it is not expected to increase again until March or April. In the Atlantic provinces scrap prices at an average of $26.50 a ton were somewhat lower than in Ontario, because of the lack of export markets. Similarly, the drop of exports to Japan kept western prices down. In the United States, the price for No. 1 heavy melting scrap declined gradually from a high of $42-43 early in the year to around $30-32 by midyear, where it remained. The reduced requirements of scrap by Japan and, to a lesser extent, western European steel producers will assure an over-all price stability in 1972 with only minor price fluctuations on a seasonal and regional basis.

Iron and steel prices

The cost of producing steel continued to rise in all major producing countries and this increase in cost was reflected in generally higher steel prices. Canadian prices for selected hot-rolled and cold-rolled products rose some 4.8 per cent in July and hot-rolled bar products rose 3.1 per cent. In Europe, according to *American Metal Market,* December 14, 1971, fob

Table 11. Steel, iron, coke and sinter and production at Canadian integrated plants[1], 1971

	Algoma							
	Sault Ste. Marie	Port Colborne	Cominco, Kimberley	Dofasco, Hamilton	Sysco, Sydney	QIT, Tracy	Stelco,[2] Hamilton	National Total
	(capacity and production in net tons)							
Crude steel, facilities Dec. 31								
Open hearth (no.)	6	–	–	–	5	–	6	17
Capacity	1,150,000	–	–	–	1,025,000	–	3,200,000	5,380,000
Basic oxygen (no.)	3	–	1	3	–	–	3	10
Capacity	1,450,000	–	75,000	3,000,000	–	–	2,200,000	6,690,000
Electric (no.)	–	–	–	7	1	–	–	. .
Capacity	–	–	–	75,850	30,000	–	–	3,397,125
Total capacity	2,600,000	–	75,000	3,075,850	1,055,000	–	5,400,000	15,461,125
Production	2,360,270	–	24,900	2,467,627	892,902	–	4,559,517	12,169,552
Pig iron, facilities Dec. 31								
Blast furnaces (no.)	4	1	–	4	2	–	4	14
Capacity	2,335,000	240,000	–	2,950,000	900,000	–	4,000,000	10,425,000[3]
Electric furnaces (no.)	–	–	2	–	–	9	–	11
Capacity	–	–	110,000	–	–	672,000	–	782,000
Total capacity	2,335,000	240,000	110,000	2,950,000	900,000	672,000	4,000,000	11,207,000[4]
Production	2,033,672	192,581	33,500	2,059,330	701,642	637,280	3,124,893	8,615,756
Coke from coal, facilities								
No. of ovens	260	–	–	211	–[6]	–	264	849
Capacity	1,485,000[5]	–	–	1,312,500	–[6]	–	1,940,000	5,349,500
Production	1,480,644	–	–	1,012,837	–[6]	–	1,824,355	4,702,836
Sinter, facilities								
No. of strands	1	–	1	–	1	–	1	8[7]
Capacity	725,000	–	190,000	–	273,000	–	900,000	2,088,000
Production	383,043	–	46,900	–	83,771	–	745,639	1,259,353

Source: Company data supplied to Mineral Resources Branch; national total from Statistics Canada, except data on coke and coal, and sinter.
[1]The seven plants listed accounted for all pig iron and 85% of crude steel produced in 1971; [2]Stelco has an electric furnace plant (132,000 t/yr capacity) at Edmonton; [3]Compared with 10,125,000 net tons reported by Statistics Canada in Primary Iron and Steel Monthly; [4]Compared with 10,907,000 net tons reported by Statistics Canada in Primary Iron and Steel Monthly; [5]Reduced from 1,670,000 tons because of shutdown of a battery for major repairs; [6]Coke ovens formerly owned by Sysco were sold to Cape Breton Development Corp. (Devco) in 1968. Devco has 114 ovens (ann cap 612,000 tons of coke) and produced 385,000 tons in 1971; [7]Includes four strands at Algoma Ore Properties Division, Wawa, Ontario.
–Nil; . . Not available.

Table 12. Canada, consumption of raw materials at pig iron and integrated steel plants, 1971

	In Sinter Plants	In Iron and Steel Furnaces: Pig Iron Furnaces[1]	Steel Furnaces	Total in Furnaces
	(net tons)			
Iron ore				
Crude and concentrate	191,813	315,662	80,363	396,025
Pellets	334,805	9,152,692	223,528	9,376,220
Sinter	105,236	3,050,737	180	3,050,917
Total iron ore	631,854	12,519,091	304,071	12,823,162
Contained iron	375,447	7,633,929	204,689	7,838,618
Other iron-bearing materials				
Flue dust	108,297	–	–	–
Scale, sponge-iron, etc.	392,232	129,174	3,199	132,373
Total	500,529	129,174	3,199	132,373
Contained iron	330,873	75,359	1,921	77,280
Other materials				
Ferromanganese	–	82	87,168	87,250
Pig iron	–	..	7,803,991	7,803,991
Scrap				
Own make	38,326	56,028	2,951,554	3,007,582
Purchased	8,667	29,673	824,257	853,930
Total	46,993	85,701	3,777,811	3,861,512
Coke	37,329	4,371,210	749	4,371,959
Stone				
Limestone	145,095	399,913	313,692	713,605
Dolomite	166,541	465,539	108,650	574,189
Total	311,636	865,452	422,342	1,287,794
Burnt stone				
Lime	–	–	257,065	257,065
Dolomite	–	–	114,177	114,177
Total	–	–	371,242	371,242

Source: Company data supplied to Mineral Resources Branch.
[1] Blast and electric furnaces.
– Nil; . . Not available.

Antwerp price in dollars a metric ton for wire rod was \$118 in November 1971, for merchant bars, \$103 and for plates, \$123. The wire rod and merchant bar prices were slightly higher than for November 1970 but the quote on plate was \$3 a metric ton lower. However, in some instances these prices are below the domestic European prices.

In the United States, attempts by one of the major steel companies early in 1971 to increase the price on steel used in construction by 12.5 per cent was frustrated by pressure from the United States Government and by the reluctance of the other major steel producers to follow the lead. However, an increase of 6.8 per cent for some major steel products was established as a compromise. Immediately following the conclusion of a labour agreement between the United Steel Workers of America and the steel industry there was an additional increase of 8 per cent in the price of some carbon and alloy steel products. Finally, the Federal Price Commission approved an increase of some 7 per cent for tin plate steel in December. Price increases in 1972 will be regulated or authorized by the Federal Price Commission working in consort with the Cost of Living Council. It is not easy to obtain specific price information about steel sales in Japan but it is generally accepted that domestic prices are increasing. Before the revaluation of the yen, Nippon Steel Corporation had announced price increases of from \$10 to \$12 on the fob price on most steel exports to the U.S.A.

Table 13. Canada, energy and reductant consumption at major integrated steel plants, 1971

	Coal	Coke	Coke Oven Gas	Tar and Pitch	Natural Gas	Fuel Oil	Oxygen	Electricity
	(net tons)	(net tons)	(mill. ft^3)	(000 imp. gal)	(000 ft^3)	(000 imp. gal)	(000 ft^3)	(mill. kwh)
In coke ovens[1]	6,760,816	–	17,278,189	–	. .	. .	–	38.1
In sinter plants	. .	36,505	392,357	–	. .	–	–	24.7
In iron furnaces	. .	3,867,882	5,518,586	. .	5,398,938	41,798	586,814	223.7
In steel furnaces	–	. .	3,884,638	4,518	2,074,680	77,948	14,615,292	372.2
Other uses	57,347	10,403	40,941,267	3,988	13,229,565	65,211	1,384,843	1,907.8
Total consumption	6,818,163	3,914,790	68,015,037	8,506	20,703,183	184,957	16,586,949	2,566.5

Source: Data supplied by companies to Mineral Resources Branch.
[1]Includes coal used by Devco which took over Sysco coke ovens, May 1, 1968.
– Nil; . . Included in total; publication would disclose individual company data.

Investment and corporate developments

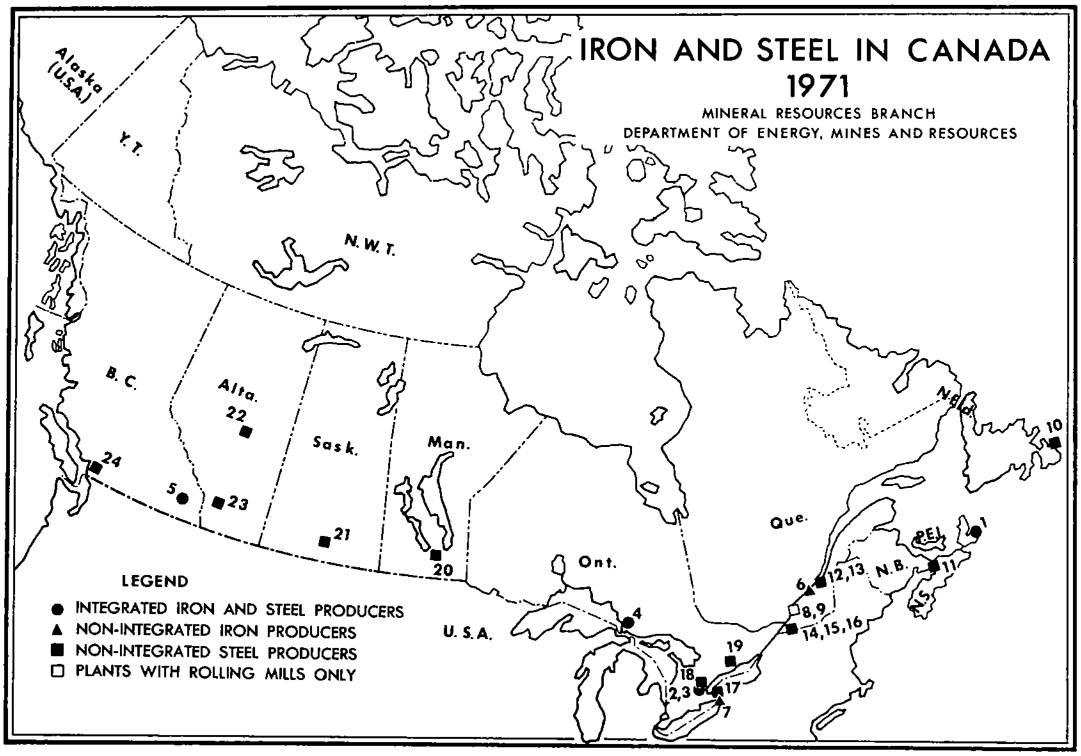
Capital and repair expenditures in the Canadian iron and steel industry in 1971 amounted to $427 million.

Plant and equipment cost figures for integrated steelmaking complexes and for the less elaborate mini-mills are highly variable. In Canada, during the ten-year period from 1961 to 1970, raw steel production capacity increased from 6.9 million tons a year to 14.1 million tons. During the decade, capital and repair expenditures for construction, machinery and equipment amounted to some $1,382.5 million, or slightly more than $190 for each increase of one ton of capacity. This does not include expenditures for some years. This figure of $190 per annual ton of capacity, for the most part, represents the cost of increasing capacity at existing plants. In the United States, a figure of $400 to $500 per ton of new installed steelmaking capacity is often cited; this may be low for the initial stages of a new plant with a capacity of 2 to 3 million tons a year. Considering the 1969-70 experience with inflation, it is almost certain to be low for future developments. Therefore, it is obvious that huge capital and repair expenditures will be necessary so that the Canadian steel industry can expand to meet domestic requirements, and to modernize and improve technology to meet foreign competition. To this must be added the yet unknown but not insignificant cost of improving our environment.

The Algoma Steel Corporation, Limited. The Algoma Steel Corporation, Limited completed installation of its $70-million, 166-inch plate mill that was in production tune-up by year-end. The mill rolls plate up to sheared widths of 153 inches to supply the growing demand for large-diameter line pipe to transport oil and gas. Work continues on the company's No. 2 basic oxygen steel plant that will be in production by early 1973 when production from open hearth furnaces will be phased out. Steel production capacity will not be increased significantly until other major facilities in the company's expansion program come on stream; raw steel production capacity is expected to be 4 million tons a year by 1975. In October, Algoma leased the seamless tube manufacturing facilities of Mannesmann Tube Company, Ltd., which Algoma will operate as a division of its Sault Ste. Marie, Ontario, operations. Other projects under way at year-end include: the relining of a small blast furnace; the installation of new coal storage and handling facilities; the replacement of the 44-inch. blooming mill with a 45-inch stand; and the installation of foundations and auxiliary equipment for a new large blast furnace.

Dominion Foundries and Steel, Limited. Dominion Foundries and Steel, Limited (Dofasco) started its new blast furnace and coking ovens early in 1971, which, along with changes in the basic oxygen shop, will increase crude steel capacity from 2.3 million tons to 2.7 million tons in 1972 and to 3.0 million tons in subsequent years. Total capital expenditures for Dofasco amounted to $85 million, of which $31 million was for the Adams Mine, near Kirkland Lake. The Adams Mine, purchased from Jones & Laughlin Steel Corporation, is an iron ore mine with an annual production capacity of 1.1 million tons of pellets. This purchase ensures that Dofasco will obtain virtually all its iron ore requirements from Canadian sources.

Dofasco's cold-rolling facilities were increased by 10 per cent in 1971 with the addition of a 56-inch



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. Cominco Ltd. (Kimberley)

Nonintegrated iron producers

6. Quebec Iron and Titanium Corporation (Sorel)
7. Canadian Furnace Division of Algoma (Port Colborne)

Plants with rolling mills only

8. Sidbec-Dosco Limited (Contrecoeur)
9. The Steel Company of Canada, Limited (Contrecoeur)

Nonintegrated steel producers
(a partial listing)

10. Newfoundland Steel (1968) Company Limited (Octagon Pond)
11. Enamel & Heating Products, Limited (Amherst)
12. Atlas Steels Division of Rio Algom Mines 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)

cold mill in the company's electric steel division. The company also started up a third electric tinning line in March 1972 that doubled tinplate capacity and is capable of conversion for the manufacture of chrome-coated steel.

International Portable Pipe Mills Ltd. International Portable Pipe Mills Ltd. commenced production of 48-inch line pipe at its new portable mill at Cochrane, Alberta, some 25 miles west of Calgary. This is the first mill of its kind in Canada in that it is entirely self-contained and can be moved distances of from 200 to 500 miles in about a month and has capacity to produce pipe up to 56 inches in diameter by 1 inch thick at the rate of 2 miles a day. The process uses plate and produces a submerged-arc welded pipe with a straight seam. Dominion Foundries and Steel, Limited and The Alberta Gas Trunk Line Company are major shareholders in this company.

Interprovincial Steel and Pipe Corporation Ltd. Interprovincial Steel and Pipe Corporation is undertaking a $5 million expansion program that will double raw steel capacity from 300,000 to 600,000 tons a year and will also involve the installation of two additional tube mills. Increased steel capacity will be achieved by the addition of a fourth electric furnace that is scheduled to be completed in November 1972. A third spiral-weld mill for tubes over 18 inches in diameter will increase large-diameter pipe capacity from 90,000 to 135,000 tons a year. These and other measures will increase the company's total rolling capacity from 500,000 to 800,000 tons per year. In addition to tubes, the company also produces structural sections, plates and strip.

Sidbec-Dosco Limited. Sidbec-Dosco Limited, the Quebec Government's steel company that operates the Montreal and Contrecoeur Works of the former Dominion Steel and Coal Corporation, Limited is in the midst of a $128-million re-equipment, improvement and expansion program, of which some $80 million will be invested in additional steelmaking capacity and $48 million will be used to expand present rolling and finishing facilities. The new metallized pellet (direct iron) plant, with a production capacity of 440,000 tons a year, is being built at Contrecoeur, Quebec, by Midland-Ross Corp. of Cleveland and is expected to commence production of reduced iron pellets sometime in 1973. The shop will remelt scrap in 1972 and has a capacity to produce from 500,000 to 550,000 tons a year, of which 350,000 tons can be cast into 3½-inch billet. By the end of 1972 or in early 1973 the steelmaking facility will be integrated from ore to ingot. The Midrex reduction plant will have an annual capacity of 440,000 tons of sponge iron of about 92 per cent metallic iron, equivalent to approximately 96 per cent reduction of the iron ore fed.

The Federal Government has announced grants totalling $6,964,000 to Sidbec in conjunction with its expansion programs at the Contrecoeur and Montreal works.

Sydney Steel Corporation. Sydney Steel Corporation (Sysco) continued with its modernization program, which began in 1970. The estimated total cost of the program is $94 million and is intended primarily to modernize the plant and increase productivity. This, in turn, is expected to increase capacity by 14 per cent from 1.1 million tons a year to 1.25 million tons. The first part of the program included degassing of open hearth steel and a modification of the rail finishing mill that will permit the production of rails up to 82 feet long. The mill now produces 39-foot rails. Subsequently the company's five open hearth steel-making furnaces will be modified so that oxygen can be injected through tuyeres set in the back wall of the furnace. The process, a modification of Germany's Maxhuette OBM process, has been tentatively called the Submerged Injection Process (SIP).

The Canadian Government, through the Department of Regional Economic Expansion, agreed to contribute up to $15.5 million as development incentive grants.

The Steel Company of Canada, Limited. The Steel Company of Canada, Limited (Stelco) completed the construction of No. 3 electrolytic tinning line at its Hilton Works. The new line is designed to produce 175,000 tons of tinplate a year at speeds of up to 1,500 feet a minute. Late in the year, capital expenditures were approved to increase finishing and shipping capacity to increase the output of the company's 148-inch plate mill and for the conversion of No. 1 rod mill to produce bars. By December, the company had completed the installation of three basic oxygen steel-producing units that will be in operation early in 1972. In addition, detailed engineering was completed on a major project that will add a new press forging plant to the company's existing facilities at Gananoque, Ontario. In July, the company announced a $1.4-million expansion program for its Notre Dame Works in Montreal.

Capital expenditures for plants and mining properties totalled $95.1 million in 1971 compared with $89.5 million in 1970. Capital projects approved during 1971 amounted to $63 million and at the end of the year the amount still to be spent on approved capital projects was approximately $123 million. Important projects to be completed in 1972 and 1973 include: extending the Hilton plant dock facilities; a battery of 83 coke ovens; a new bloom and billet mill; expanding of finishing and stripping facilities in the 148-inch plate mill; and the conversion of the No. 1 rod mill for the production of bars.

It is not expected that the additional capacity of the projected Nanticoke steel plant on Lake Erie will be required before the late 1970's and planning and engineering studies are continuing accordingly.

Canada, tariffs on selected iron and steel materials

Item No.		British Preferential	Most Favoured Nation	General
32905-1	Iron ore	free	free	free
37301-1 37302-1 37303-1	Iron and steel scrap	free	free	free
37400-1	Pig iron, nop, per ton	free	free	$2.50
37600-1	Sponge iron	free	free	free
37700-1	Ingots of iron or steel, nop, per ton	free	free	$5
37800-1	Iron or steel, semifinished, namely: blooms,	(%)	(%)	(%)
	slabs, billets, or sheet bars	free	5	10
37900-1	Bars or rods hot-rolled	5	10	20
37905-1	Bars or rods cold-rolled	5	12½	25
37915-1	Rods for wire manufacture, per ton	free	$3	$5
37920-1	Rods for fencing wire manufacture, per ton	free	free	$5
37950-1	Shapes or sections of iron or steel, nop, not		(%)	(%)
	further manufactured than extruded or drawn	10	12½	35
38001-1	Angles, beams, channels, tees, zees and other shapes or sections, nop	5	10	20
38002-1	Large sections, not made in Canada, per ton	free	$5	$20
38100-1	Plate, hot- or cold-rolled		(%)	(%)
		5	10	20
38105-1	Plate, flanged or dished	5	15	30
38110-1	Plate, or iron or steel, nop sheet or strip	5	12½	25
38201-1	Sheet or strip hot-rolled	5	10	20
38202-1	Sheet or strip cold-rolled	5	12½	25
38203-1	Sheet or strip coated with tin or enamel	10	12½	25
38204-1	Sheet or strip coated with zinc	7½	12½	25
38205-1	Sheet or strip coated, nop	7½	12½	20
38400-1	Skelp (plate, sheet strip, hot- or cold-rolled for mfg. pipe, tubes)	free	7½	15
38700-1	Rails	5	10	20
39000-1	Castings, rough, nop	15	15	27½
39005-1	Piston ring castings, rough	free	free	27½
39101-1	Ingots moulds for steel production	free	free	free
39102-1	Ingot moulds, nop	free	7½	10
39200-1	Forgings	15	17½	30
39900-1	Pipes, large diameter	10	15	30
40101-1	Wire, round, nop	2½	7½	20
40102-1	Wire, other, nop	5	10	20
40103-1	Wire, coated or covered, nop	5	10	20

Source: The Custom Tariff and Amendments, Department of National Revenue, Customs and Excise Division. Further details and specific variations may be obtained from the above authority.
nop Not otherwise provided for.

Lead

J.G.GEORGE

In 1971 Canada's production of lead, based on lead recovered from domestic ores and concentrates and the recoverable lead content of ores and concentrates exported, increased 4.5 per cent from 1970. Much higher production by Anvil Mining Corporation Limited, in the Yukon Territory, accounted for most of the increase. The remainder of the increase came largely from greater output by the Sullivan mine of Cominco Ltd. in British Columbia and by Brunswick Mining and Smelting Corporation Limited in New Brunswick. In June 1971 operations were suspended at the lead-zinc-silver mine and mill of Venus Mines Ltd. in the Yukon Territory and at the lead-zinc-silver mine and mill of Copperline Mines Ltd. in southeastern British Columbia. Both mines had only begun operations about October 1970. In December 1971 Cominco Ltd. closed down its Bluebell lead-zinc-silver mine in southeastern British Columbia and on January 4, 1972 Nigadoo River Mines Limited announced that it was immediately suspending mining and milling operations at its lead-zinc-copper-silver property near Bathurst, New Brunswick. Because of lower prices, the value of Canadian lead mine production was some $13.3 million lower than that of 1970.

Primary refined lead output totalled 185,582 short tons* compared with 204,630 tons in 1970. Cominco Ltd. operated its smelter and refinery at Trail, British Columbia, at somewhat less than capacity of 210,000 tons annually. The lead refinery of Brunswick Mining and Smelting Corporation Limited, Smelting Division (formerly East Coast Smelting and Chemical Company Limited) at Belledune, New Brunswick, with annual capacity of 30,000 tons, remained Canada's only other producer of primary lead metal.

Most of the lead ores and concentrates from western Canada were treated by Cominco Ltd. at Trail, British Columbia; the remainder were treated at plants in northwestern United States, Europe and Japan. Lead concentrates produced in eastern Canada, excluding that portion of the output of Brunswick Mining and Smelting Corporation Limited smelted at the Belledune plant, were shipped to Trail, British Columbia and smelters in the United States and Europe.

Exports of lead contained in ores and concentrates were 20 per cent higher than in 1970, with almost 60 per cent going to Japan and most of the remainder shipped to West Germany, the United States and Belgium. Metal exports in 1971 were more than 10 per cent less than in 1970. The United States and Britain continued to be the major customers. Imports of refined lead metal were 4,632 tons compared with 2,199 tons in 1970.

Statistics are not yet available for Canadian consumption of lead metal in 1971 but in 1970 reported consumption of primary and secondary lead was 60,143 and 33,294 tons, respectively.

United States imports and stockpiles

United States imports of lead metal and lead in ores and concentrates totalled 261,600 tons in 1971, about 27 per cent less than in 1970. The reduction occurred in about equal amounts in imports of metal and lead in ores and concentrates. The decrease resulted mainly from a domestic oversupply of lead which developed largely as a result of the continued slowdown in the United States economy. Other contributing factors were the dock strikes at United States ports and the increases in the import tariffs which latter became effective in August 1971 and were rescinded in December of the same year.

*Wherever used in this review, the term 'ton' refers to the short ton of 2,000 pounds avoirdupois, unless otherwise stated.

Table 1. Canada, lead production, trade and consumption, 1970-71

	1970		1971p	
	(tons)	($)	(tons)	($)
Production				
All forms[1]				
British Columbia	107,419	33,987,455	123,634	33,381,000
Yukon Territory	65,835	20,830,196	108,093	29,185,000
Northwest Territories	119,603	37,842,405	83,387	22,514,000
New Brunswick	62,675	19,830,329	71,391	19,275,000
Newfoundland	17,730	5,609,750	9,767	2,637,000
Ontario	11,960	3,784,166	9,215	2,488,000
Quebec	2,159	682,993	608	164,000
Nova Scotia	1,299	410,967	415	112,000
Manitoba	505	159,813	175	47,000
Total	389,185	123,138,074	406,685	109,803,000
Mine output[2]	393,740		433,465	
Refined production[3]	204,630		185,582	
Exports				
Lead contained in ores and concentrates				
Japan	77,080	17,072,000	118,310	20,612,000
West Germany	22,347	4,037,000	31,141	4,914,000
United States	41,020	8,118,000	24,176	4,222,000
Belgium-Luxembourg	20,456	3,614,000	16,129	2,349,000
Italy	–	–	3,926	452,000
Britain	2,833	492,000	2,485	384,000
Mexico	–	–	2,497	233,000
Other countries	2,176	360,000	654	132,000
Total	165,912	33,693,000	199,318	33,298,000
Lead in pigs, blocks and shot				
United States	56,965	16,444,000	58,361	13,873,000
Britain	56,217	15,010,000	46,557	10,052,000
India	18,909	5,088,000	15,484	3,300,000
Italy	2,848	791,000	6,070	1,277,000
Netherlands	5,302	1,363,000	5,682	1,191,000
Pakistan	1,959	603,000	1,934	387,000
West Germany	3,975	1,114,000	995	206,000
Taiwan	474	130,000	441	97,000
Norway	434	122,000	362	75,000
Philippines	–	–	355	71,000
Hong Kong	33	9,000	121	26,000
Other countries	5,705	1,470,000	522	109,000
Total	152,821	42,144,000	136,884	30,664,000
Lead and lead alloy scrap (gross weight)				
Belgium-Luxembourg	1,113	237,000	2,511	605,000
United States	1,901	592,000	1,418	266,000
Netherlands	100	14,000	522	71,000
Brazil	–	–	407	56,000
Other countries	2,628	524,000	990	192,000
Total	5,742	1,367,000	5,848	1,190,000

Table 1 (Cont'd)

	1970 (tons)	1970 ($)	1971p (tons)	1971p ($)
Lead fabricated materials, not elsewhere specified				
United States	6,582	3,316,000	3,614	1,236,000
South Africa	–	–	126	133,000
Australia	20	11,000	10	5,000
Other countries	24	17,000	7	5,000
Total	6,626	3,344,000	3,757	1,379,000
Imports				
Lead pigs, blocks and shot	2,199	668,000	4,632	1,294,000
Lead oxide; litharge, red lead, mineral orange	1,878	672,000	3,029	825,000
Lead fabricated materials, not elsewhere specified	382	334,000	371	238,000
Total	4,459	1,674,000	8,032	2,357,000

	1970 Primary	1970 Secondary[4]	1970 Total	1971p Primary	1971p Secondary[4]	1971p Total
		(tons)			(tons)	
Consumption						
Lead used for, or in the production of						
antimonial lead	1,475	*	*	1,688	..	..
battery and battery oxides	20,273	3,731	24,004	23,448	2,797	26,245
cable covering	2,296	*	*	2,350	..	..
chemical uses: white lead, red lead, litharge, tetraethyl lead, etc.	22,058	*	*	21,116	..	..
copper alloys: brass, bronze, etc.	318	*	*	419	..	..
Lead alloys						
solders	2,527	2,976	5,503	2,330	1,870	4,200
other (including babbitt, type metal, etc.)	276	3,313	3,589	221	3,087	3,308
Semifinished products: pipe, sheet, traps, bends, blocks for caulking, ammunition, foil, collapsible tubes, etc.	8,620	495	9,115	6,165	435	6,600
Other	2,457	1,615	4,072	2,241	1,200	3,443
Total, all categories	60,300	33,794	94,094	59,978	34,639	94,617

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 exported. [2]Lead content of domestic ores and concentrates produced. [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; *Not available for publication.

Table 2. Canada, lead production, trade and consumption, 1962-71

	Production		Exports				
	All Forms[1]	Refined[2]	In Ores and Concentrates	Refined	Total	Imports, Refined[3]	Consumption[4]
	(tons)	(tons)	(tons)	(tons)	(tons)	(tons)	(tons)
1962	215,329	152,217	59,495	125,802	185,297	578	77,286
1963	201,165	155,000	53,756	97,144	150,900	1,741	77,958
1964	203,717	151,372	80,357	95,867	176,224	73	82,736
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	132,320	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
1971p	406,685	185,582	199,318	136,884	336,202	4,632	. .

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.
pPreliminary; . . Not available.

In July 1969, the United States Government authorized the release of 100,000 tons of lead from the government's national stockpiles. All sales were to be made by General Services Administration (GSA) and were for domestic consumption only. Up to the end of 1971 some 22,700 tons were sold (of which none was sold in 1971), leaving an unsold balance of 77,300 tons. Of a prior stockpile release of 50,000 tons for government use only, authorized in April 1965, about 27,950 tons had been sold by the end of December 1971. The lead inventory in the stockpile at the end of 1971 amounted to some 1.13 million tons, of which 0.60 million tons were considered to be surplus to conventional and nuclear war requirements. The stockpile objective remained at 530,000 tons.

Of the total industrial stocks of 204,900 tons on hand at the end of 1971, 118,700 tons were in the hands of consumers with the remainder held by producers. Corresponding figures at the end of 1970 were 231,400 and 117,600 tons, respectively.

Early in 1970 officials of the United States Government administration and representatives of the lead producing industry began closed discussions of a proposal for the industry to dispose of the excess inventory of lead in the government stockpile, then amounting to 623,000 tons. The plans were eventually shelved. On February 11, 1971 Bill S.764 was introduced in the Senate to dispose of 498,000 tons of lead from the national and supplemental stockpiles. Hearings were conducted on this Bill by the Senate Armed Services Subcommittee in April and September 1971 but no final action was taken. The plans called for flexible quarterly sales quotas and envisaged a long-range disposal program, possibly over a period of 10 years or more, whereby about 50,000 tons of lead would be sold annually, with sales restricted to United States domestic producers of lead.

On May 19, 1971 Bill H.R. 8587, to alter the existing rates of import duties applicable to lead and zinc ores, concentrates and metal, was introduced in the House of Representatives. No final action was taken on the Bill which is referred to as "The Lead and Zinc Act of 1971".

The 10 per cent ad valorem import surcharge announced by President Nixon on August 15, 1971 had the effect of raising the duty, effective August 16, 1971, on imports of Canadian lead metal from 1.0625 to 2.125 cents a pound and on lead in ores and concentrates from 0.75 to 1.5 cents a pound. On December 20, 1971 the President signed a proclamation rescinding immediately this 10 per cent surcharge on foreign imports.

World production and consumption

Noncommunist world mine production of lead, according to statistics published by the International Lead and Zinc Study Group, was 2.86 million tons in 1971, or about 1 per cent higher than in 1970. A significant increase in Canadian output, together with greater production in Japan, the Republic of South Africa, Yugoslavia, Mexico and other countries, more than offset substantial declines in Australia and Ireland and reduced output in some other countries. Canada became the noncommunist world's second largest mine producer, with the United States retaining its position as the leading producer. Noncommunist world production of primary and secondary refined lead totalled an estimated 3.50 million tons, or some 180,400 tons less than in 1970. The United States.

Britain, Mexico and West Germany reported the largest quantitative decreases in refined lead production.

Mine production of lead in the United States rose insignificantly from 595,600 tons in 1970 to 596,000 tons in 1971. Output from the State of Missouri again represented about 75 per cent of United States production. Primary refined lead production in the United States totalled 654,392 tons in 1971 compared with 674.366 tons in 1970.

Consumption of lead in the noncommunist world rose in 1971 to a new record high of 3.59* million tons, an increase of almost 5 per cent from 1970. The United States remained, by far, the world's largest consumer, using 1.29** million tons or some 43,800 tons** more than in 1970. Significant increases in the requirements of lead for storage batteries, ammunition and collapsible tubes more than offset declines in several uses for lead, including that for gasoline antiknock additives.

In reviewing the statistical position and outlook for lead at its November 1971 meeting in Torremolinos, Spain the International Lead and Zinc Study Group noted that lead and zinc have both been affected by the general slowing-down in economic growth and the present uncertainties in the international trade and monetary situation. In a press release at the close of the Group's fifteenth annual session, it predicted a strong rise in production of lead during 1972, with the possibility of a surplus of supply over demand developing unless there is continued restraint on output. For 1972 the Study Group forecast that lead supply would exceed demand by 4.5 per cent. Referring to lead prices, the Study Group said that their decline to the lowest levels for several years on the London Metal Exchange (LME) was causing much concern at a time of strongly rising costs. However, the prospect of an eventually improved balance between supply and demand and a further reduction in the level of producers' stocks could strengthen the market, the Group surmised. The Study Group also dealt with the situation pertaining to lead in gasoline and said that it seems unlikely that there will be any significant decrease in total consumption of lead for gasoline in the next few years.

There were only two significant changes in lead smelter capacity in 1971. The first was the closing down early in the year of the lead smelter and refinery

*Preliminary estimate. **Figures reported in International Lead and Zinc Study Group, Monthly Bulletin, May 1972.

Table 3. Noncommunist world mine production of lead, 1970-71

	1970	1971p
	(tons)	
United States	595,600	596,000
Canada	393,700	436,700
Australia	485,300	429,700
Mexico	189,100	191,500
Peru	180,800	180,800
Yugoslavia	120,500	123,200
Morocco	89,300	..
Sweden	84,300	85,600
Republic of South Africa	77,700	80,700
Japan	71,000	79,400
Spain	76,600	75,900
Ireland	69,200	50,500
West Germany	47,100	49,100
Argentina	40,800	39,700
Italy	38,800	33,800
Other countries	268,000	402,800
Total	2,827,800	2,855,400[1]

Source: International Lead and Zinc Study Group, Monthly Bulletin, May 1972.
[1]Total includes estimates for those countries for which figures are not available.
pPreliminary; .. Not available.

Table 4. Noncommunist world production[1] of refined lead, 1970-71

	1970	1971p
	(tons)	
United States	1,165,600	1,107,700
West Germany	333,900	313,200
Britain	316,300	292,500
Japan	230,400	237,000
Australia	227,100	206,900
Canada	204,600	185,500
France	187,400	177,600
Mexico	192,600	170,500
Yugoslavia	107,400	108,000
Belgium	98,500	88,300
Italy	87,400	87,400
Spain	79,600	81,500
Peru	79,400	77,700
Republic of South Africa	74,800	75,400
Sweden	62,900	49,400
Other countries	236,800	245,700
Total	3,684,700	3,504,300

Source: International Lead and Zinc Study Group, Monthly Bulletin, May 1972.
[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.
pPreliminary.

at Selby, California. This custom smelter, which had been in continuous operation since 1885, had for several years been operating at only 50 to 60 per cent of capacity. A combination of rising costs and changing patterns in world trade finally made it economically obsolete. The second was brought about by the announcement early in November 1970 by The Anaconda Company that at the end of 1971 it was closing down the lead smelter at Tooele, Utah operated by its subsidiary, International Smelting and Refining Company. Rising operating costs over the past 5 years and a drop in smelter feed were given as the reasons for closing the plant, which began lead smelting operations in 1912 and had an annual rated capacity of 66,000 tons of lead bullion. In 1970, the Tooele plant produced about 38,000 tons of lead bullion, including 26,000 tons under tolling contracts. Another change in 1971 was an increase in productive capacity at a conventional lead smelter in Japan from 32,000 to 40,000 tons a year. In 1972 an Imperial Smelting Furnace (ISF) plant is scheduled to open in Italy at an initial operating rate of 22,000 tons of refined lead annually, to be increased in 1973 to 44,000 tons annually. Another ISF plant, with annual capacity of 33,000 tons, was planned for installation in Yugoslavia with operations due to start in 1973.

In 1971 two new lead-producing mines began operations; one in Nicaragua and the other in the United States. Two other lead mines expanded existing output; one in Japan and the other in Peru. In 1972 three new lead-producing mines are scheduled to begin operations; one in Morocco, the second in Peru and the other a zinc-copper-silver property in the Sturgeon Lake area of northwestern Ontario to be operated by Mattabi Mines Limited. Expansion of existing output is planned for a mine in Australia, one in Peru and another in Yugoslavia. In 1973 one new lead-producing mine is expected to begin operations in the New Missouri Lead Belt district of southeastern Missouri. Expansion of existing facilities is planned for another lead-producing mine in Japan. Two new lead-producing mines are scheduled to begin operations in Spain in 1975.

Outlook

Canada's mine production of lead in 1972 is forecast to be some 415,000 tons and during the period 1973-77 it could range between 425,000 and 500,000 tons annually.

The lead industry is faced with both problems and opportunities. There is reason for concern in the threatened elimination of lead additives from gasoline, one of the metal's major uses, in order to meet governmental regulations to control pollution. In 1971 lead used in antiknock additives in gasoline in the United States represented some 19 per cent of total consumption. However, although total United States consumption of lead increased slightly in 1971, the amount of lead used in tetraethyl lead in that same country in the same year was more than 5 per cent less than in 1970, and this declining trend could continue. The use of lead in cable sheathing, when expressed as a percentage of total consumption, is expected to decline, although no reduction is anticipated in absolute terms. The use of lead in typesetting may also have reached its peak. Materials have been developed to replace lead in paints; it is seldom used in interior paints and has been essentially replaced in exterior house paints by titanium and zinc pigments. However, as a basic paint for rust and corrosion protection in structural and highway use, lead is still the preferred base material.

The slack will, however, be partly offset by the growing use for lead in batteries. The brightest future for the metal still appears to be in its use for lead-acid storage batteries, mainly as a result of the continuing development of the lead-acid battery-powered passenger vehicle. There is little indication at this time that any no-lead battery now know or foreseen could be economically considered as such a power source in place of the conventional lead-acid battery. Some experts predict that by 1980 there will be a 50 per cent increase in this application of lead, which is the metal's major use throughout the world.

Other problems facing the lead industry are the current recession and inflationary state of the economy in the United States and other countries, and the world monetary confusion. However, the discarding of the floating currencies and the return to fixed parities agreed to amongst the leading western nations late in December 1971 restored some stability to the monetary situation. Also, the economies of the United States and other countries are showing some signs of recovery.

Because of the trend toward self-sufficiency in the United States – which for many years has been Canada's most important foreign lead market – resulting from rising output in the New Missouri Lead Belt area, a greater part of Canada's exports may have to find outlets in other countries. Surplus government stocks of lead represent an additional source of supply in the United States. Canadian lead exporters may face increasing competition from a growing mine output of lead in Ireland that must seek foreign markets. This competition could become somewhat keener if the big Navan orebody, discovered in November 1970 in County Meath, Ireland, by Tara Exploration and Development Company Limited, is brought into production. It is a zinc-lead deposit and latest estimates indicate it contains some 30 million tons of ore averaging a combined 11 per cent zinc and lead content.

Canadian developments

Yukon Territory. A sharp increase in lead output in 1971 in the Yukon Territory again resulted from much greater production at the lead-zinc-silver property of Anvil Mining Corporation Limited. Also con-

Table 5. Principal lead (mine) producers in Canada, 1971

Company and Location	Mill Capacity	Grade of Ore Milled in 1971 (principal metals) Lead	Zinc	Copper	Silver	Ore Produced 1971 [1970]	Lead in Concentrates and Direct-Shipping Ores 1971 [1970]	Remarks
	(tons of ore/day)	(%)	(%)	(%)	(troy oz/ton)	(tons)	(tons)	
Yukon Territory								
Anvil Mining Corporation Limited, Faro	7,700	4.92	6.74	–	..	2,673,000 [1,961,000]	113,352 [63,476]	Mill capacity increased from 6,600 to 7,700 tons a day
United Keno Hill Mines Limited, Hector-Calumet, Elsa, Husky and No Cash mines, Mayo district	550	5.17	5.19	–	30.57	94,754 [93,215]	4,417 [3,473]	Hydraulic fill plant to be installed for cut-and-fill method of stoping at Husky mine
Venus Mines Ltd. Carcross	300	..	..	..	..	.. [23,796]	.. [197]	Operations suspended in June 1971
Northwest Territories								
Pine Point Mines Limited, Pine Point	10,000	2.6	6.5	–	..	3,891,927 [3,859,838][1]	95,849 [101,780]	First phase of underground test stoping program completed in 1971; next phase, to determine mining factors, planned for 1972
British Columbia								
Canadian Exploration, Limited Jersey mine, Salmo	1,900	–	–	–	–	– [216,000]	– [2,275]	Jersey zinc-lead mine ceased operations August 1, 1970 because of depletion of ore reserves; existing tungsten mill rehabilitated, began tune-up operations October 1970
Cominco Ltd. Sullivan mine, Kimberley	10,000	..	..	–	..	2,005,301 [2,194,743]	113,414 [98,664]	At December 31, 1971 total ore reserves at Sullivan, Bluebell and H.B. (not operating) mines were 65 million tons containing 7.0 million tons of combined lead and zinc

Bluebell mine, Riondel	750	..	..	–	..	256,797 [245,529]	10,505 [10,446]	Operations suspended in December 1971 because of depletion of ore reserves
Copperline Mines Ltd. Ruth-Vermont mine, Golden	600	..	..	–	..	58,593 [36,228]	.. [1,097]	Mill tune-up operations began in September 1970, suspended in June 1971
Kam-Kotia Mines Limited Silmonac mine, Slocan district	150	6.39	6.60	–	17.99	39,154 [13,232]	2,377 [942]	Mill tune-up operations began September, 1970
Reeves MacDonald Mines Limited	1,000 (treated at central mill)							
Reeves mine, Remac		1.41	4.50	..	..	25,296 [107,312]	275 [1,337]	Operations curtailed in July 1971 due to depletion of known ore reserves
Annex mine, Remac		0.89	8.63	..	2.51	166,089 [70,714]	1,334 [647]	Exploration work continuing
Teck Corporation Limited, Beaverdell mine, Beaverdell (formerly Leitch Mines Limited)	115	0.70	0.80	–	17.52	36,404 [33,225]	256 [297]	At current silver prices there appears to be sufficient ore developed for at least two years of operation
Dankoe Mines Ltd. (formerly Utica Mines Ltd.), Keremeos	350,	–	–	–	–	– [18,603]	– [12]	Mill ceased operations March 31, 1970
Western Mines Limited, Buttle Lake, Vancouver Island	1,000	0.70	6.9	2.0	1.6	386,541 [386,976]	2,243 [2,387]	Decline at Myra Falls property advanced 935 feet to completion
Manitoba-Saskatchewan								
Hudson Bay Mining and Smelting Co., Limited	6,000 (treated at central mill at Flin Flon)							Production curtailed as entire Flin Flon and Snow Lake operations closed down from January 27, 1971 to June 21, 1971 because of labour strike
Chisel Lake mine, Snow Lake, Man.		0.3	8.4	1.0	0.9	163,200 [281,500]	206[2] [515][2]	
Ontario								
Big Nama Creek Mines Limited, Manitouwadge	Ore custom-milled	0.06	5.12	0.81	1.07	41,717 [88,965]	[8]	Mining operations suspended in September 1971 because of depletion of known ore reserves

Table 5. (Cont'd)

Company and Location	Mill Capacity	Grade of Ore Milled in 1971 (principal metals) Lead	Zinc	Copper	Silver	Ore Produced 1971 [1970]	Lead in Concentrates and Direct-Shipping Ores 1971 [1970]	Remarks
	(tons of ore/day)	(%)	(%)	(%)	(troy oz/ton)	(tons)	(tons)	
Ecstall Mining Limited (Texas Gulf Sulphur Company), Kidd Creek mine, Timmins	10,000	0.35	9.74	1.38	4.05	3,673,350 [3,584,124]	8,761 [9,349]	Shaft from surface to 3,050 feet completed in August 1971
Noranda Mines Limited, Geco Division, Manitouwadge	5,000	. .	5.52	2.27	2.03	1,759,952 [1,366,176]	1,389 [1,742]	Company plans to install system to recycle tailings water back to mill for processing
Willroy Mines Limited, Willroy and Willecho mines, Manitouwadge	1,600	0.13	3.33	0.89	1.36	427,589 [388,005]	317 [538]	1971 production figures include output from Big Nama Creek Mines Limited; ore grades are averages including Big Nama production
Quebec								
D'Estrie Mining Company Ltd., Stratford Centre	Ore custom-milled	0.57	2.52	2.11	0.974	83,506 [. .]	225 [. .]	Normal development and stope preparations to continue
Manitou-Barvue Mines Limited, Golden Manitou mine, Val d'Or	1,600	1.42	1.96	. .	4.42	225,915[3] [273,200][3]	651 [774]	Due primarily to lower silver prices, mining and milling of company's silver-zinc orebody temporarily suspended October 29, 1971
Sullivan Mining Group Ltd., Cupra Division,[6] Stratford Centre	1,400	0.63	3.86	2.29	1.05	134,663 [193,450]	390 [279]	Ore reserves at August 31, 1971 were 521,000 tons averaging 2.49 per cent copper, 0.60 per cent lead, 3.58 per cent zinc and 1.00 oz silver a ton
Sullivan Mining Group Ltd., Solbec Dicision,[6] Stratford Centre	Ore custom-milled	–	–	–	–	– [132,060]	– [738]	Mine closed in December 1970 because of exhaustion of ore reserves

New Brunswick								
Brunswick Mining and Smelting Corporation Limited, No. 12 mine,[4] Bathurst	6,000	3.25	8.11	0.30	2.44	1,567,000 [1,519,981]	. . [26,612]	Accelerated stope development program to increase production from mechanized cut-and-fill stopes under way; should be completed in 1972
No. 6 mine,[5] Bathurst	3,500	2.11	5.76	0.36	1.86	847,000 [1,100,703]	. . [14,350]	No. 6 mill shut down from late June to mid-October 1971 to convert it to make separate lead and zinc concentrates instead of bulk zinc-lead concentrates
Heath Steele Mines Limited, Newcastle	3,000	2.23	5.29	0.97	2.21	972,456 [1,030,899]	10,322 [12,324]	Plans to sink No. 5 shaft in "B" zone orebody
Nigadoo River Mines Limited,[6] Bathurst	1,000	2.53	2.66	0.27	3.37	322,956 [319,689]	7,771 [7,348]	Mining and milling operations suspended January 4, 1972 following labour strike which began late in November 1971; resumption of operations dependent on improved metal prices and better economic conditions
Nova Scotia								
Dresser Minerals, Division of Dresser Industries Inc., Walton	140	3.3	0.5	0.36	4.35	16,125 [27,263]	514 [1,478]	Developed small cut-and-fill stopes where possible
Newfoundland								
American Smelting and Refining Company (Buchans Unit), Buchans	1,250	6.90	12.39	1.08	3.71	173,000 [359,000]	11,253 [24,103]	Production curtailed by labour strike which began June 21, and ended November 12, 1971

Source: Company reports.
[1]Figure represents tons of ore milled. In 1970, company also produced 92,600 tons of direct-shipping ore of grade averaging 14.5 per cent lead and 21.5 per cent zinc. [2]Lead content of lead concentrates only. [3]Production does not include copper ore milled in separate circuit. [4]Grades and production for 1971 represent ore produced at No. 12 mine only. [5]Grades and production for 1971 represent ore produced at No. 6 mine only. An additional 625,000 tons of ore produced at the No. 6 mine was treated in the No. 12 mill. [6]Production for fiscal years ending August 31.
– Nil; . . Not available.

tributing to the Territory's increase was somewhat higher output at the lead-zinc-silver property of United Keno Hill Mines Limited near Mayo. Hudson Bay Mining and Smelting Co., Limited continued development work at its silver-lead-zinc 'Tom' claims on the Canol Road near the Yukon Territory-Northwest Territories border. Diamond drilling and underground development work have indicated that the east and west zones now contain an estimated 8,600,000 tons grading 8.1 per cent lead, 8.4 per cent zinc and 2.75 ounces of silver a ton. Matt Berry Mines Limited continued exploration work on its silver - base-metals property in the Frances Lake area of the Yukon Territory. It is a joint venture project with Canadian Nickel Company Limited (a subsidiary of The International Nickel Company of Canada, Limited) and Metallgesellschaft Canada Limited. Previous diamond drilling indicated a deposit containing 415,000 tons with grade averaging 9.12 per cent lead, 6.25 per cent zinc and 4.33 ounces of silver a ton.

Northwest Territories. Output by Pine Point Mines Limited, 69 per cent owned by Cominco Ltd., at its zinc-lead property near Pine Point on the south shore of Great Slave Lake, was somewhat reduced from that of 1970 because of the lower grade of ore treated. Cominco Ltd. made a significant discovery of zinc-lead ore on Little Cornwallis Island. Nine widely spaced drill holes indicated substantial thicknesses of mineralization assaying more than 20 per cent combined zinc and lead. Geological evidence suggests the occurrence of a major deposit. The property is held by Arvik Mines Ltd., in which Cominco holds a 75 per cent interest; the remaining 25 per cent interest is owned by Bankeno Mines Limited.

British Columbia. Cominco Ltd. operated two lead-zinc mines in the southeastern part of the province – the Sullivan and Bluebell. Concentrates from these mines, from Pine Point Mines Limited and from custom suppliers were treated at Cominco's metallurgical works at Trail which include a lead smelter and refinery. The construction at Trail of a pilot plant to test the company's unique oxygen lead smelting process was nearing completion at the end of 1971. This plant will have a daily capacity of 60 tons of lead bullion and the object of this large-scale test is to establish the design data for a full-size plant. In December 1971, operations were suspended at the Bluebell property because of exhaustion of ore reserves. The mine had been in operation intermittently between 1895 and 1952 and had been in continuous operation since 1952. It was British Columbia's oldest known lead-zinc mine.

New Brunswick. The base-metal property of Brunswick Mining and Smelting Corporation Limited near Bathurst continued to be the principal lead producer in New Brunswick, accounting for almost 75 per cent of provincial output. In November 1971 arrangements were concluded to convert the ISP (Imperial Smelting Process) lead-zinc smelter of Brunswick Mining and Smelting Corporation Limited, Smelting Division, at Belledune to a lead smelter processing lead concentrates only. The conversion was expected to cost $10 million and require 18 months to complete. A preliminary conversion was made in January 1972, with major changes to follow in November 1972 and mid-1973. In the first quarter of 1972, lead smelting operations had approached planned levels of 3,500 tons of refined lead a month.

Surface diamond drilling and exploration work continued at the lead-zinc-silver deposit jointly held by North American Rare Metals Limited and Mistango River Mines Limited. The property is in the Millstream River area about 20 miles west of Bathurst. Late in 1971, a diamond drilling program got under way on a group of mining claims adjoining the east boundary of Heath Steele Mines Limited in the Bathurst-Newcastle area. The claims contain lead and other base-metal mineralization. Dejour Mines Limited holds a 25 per cent interest in the project, with similar interests held by Canadian Reynolds Metals Company, Limited, Discovery Mines Limited and Lynx-Canada Explorations Limited.

Because of metallurgical difficulties, The Anaconda Company (Canada) Ltd. suspended operations in November 1971 at the copper ore zone of its Caribou property in the Bathurst district of New Brunswick. The company also discontinued exploration and development work at its main Caribou zinc-lead-copper-silver deposit. The property is owned 75 per cent by Anaconda and 25 per cent by Cominco Ltd., with Anaconda being in charge of operations.

Newfoundland. American Smelting and Refining Company, Buchans Unit, was again the only lead producer in Newfoundland. The company operated a 1,250-ton-a-day mill at Buchans in the central part of the province and produced lead, zinc, copper and precious metals concentrates. Its lead output in 1971 was, however, substantially below that of 1970 because of a labour strike which caused a suspension of operations from June 21 to November 12, 1971.

Uses

Lead has many useful chemical and mechanical properties and because of this versatility it has a variety of industrial applications. It is soft and ductile. It alloys readily with many other materials, has good corrosion resistance, a high boiling point, a low melting point and a high specific gravity.

The major use for lead is in lead-acid storage batteries, the bulk of which is used for starting and lighting in automobiles and trucks. There are also new and expanding markets for such storage batteries in electric-powered passenger cars and industrial vehicles, and certain household appliances. Recent improve-

Table 6. Prospective[1] lead producing mines in Canada

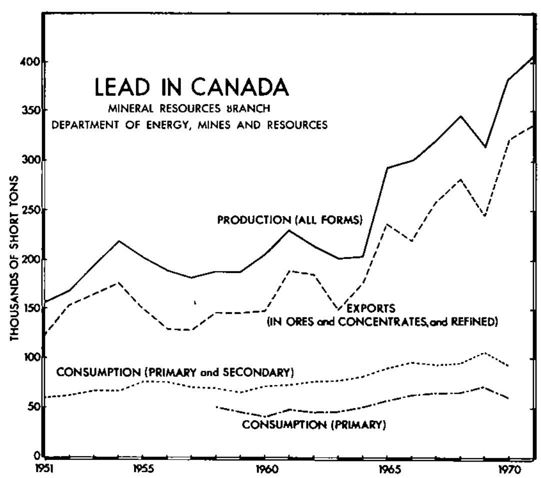
Company and Location	Year Production Expected	Mill or Mine Capacity	Indicated Ore Reserves	Average Grade of Ore Lead	Zinc	Copper	Silver	Remarks
		(tons ore/day)	(tons)	(%)	(%)	(%)	(troy oz/ton)	
British Columbia								
Nadina Explorations Limited, Owen Lake area	1972	500	450,000	1.60	7.1	0.81	9.72	Bralorne Can-Fer Resources Limited and Pacific Petroleums, Ltd. invested funds on a 50-50 basis to bring the Nadina property into production. Bralorne will manage the project
Ontario								
Mattabi Mines Limited, Sturgeon Lake area	1972	3,000	12,900,000	0.84	7.6	0.91	3.13	Initial open-pit production expected to begin during third quarter of 1972

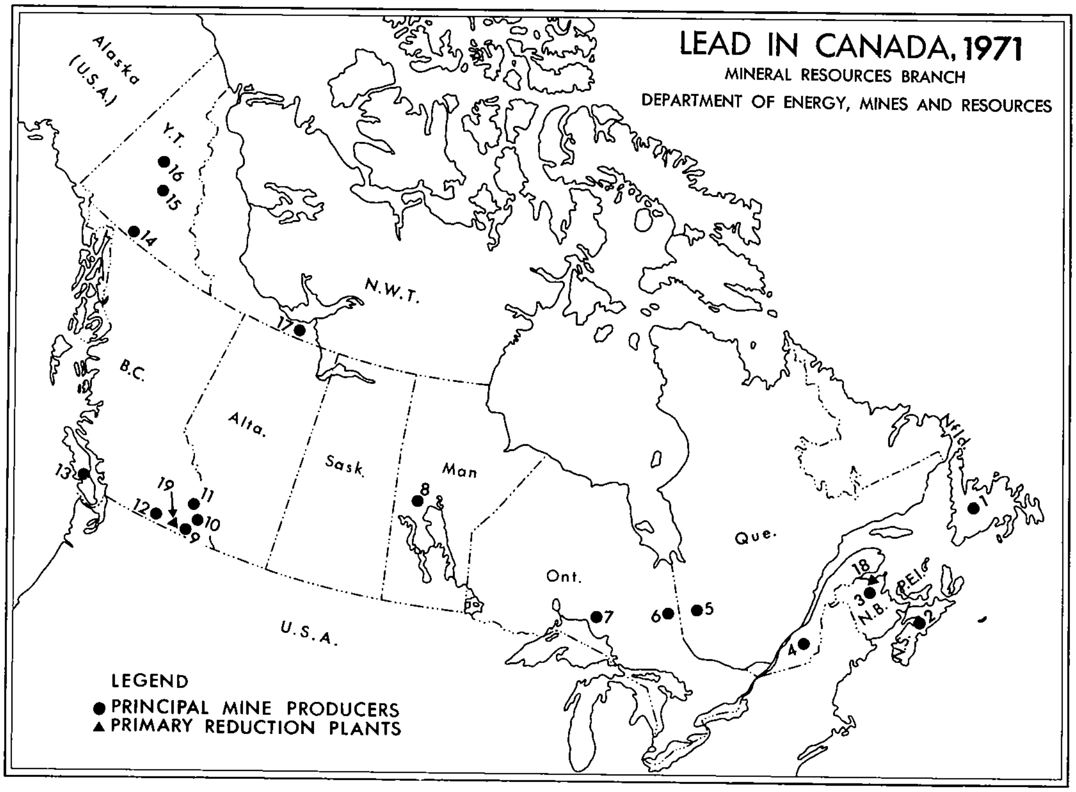
[1]Those mines which have announced production plans.

ments in battery manufacture have, however, significantly reduced the weight of lead per battery unit and increased the average battery life. Lead's next important use is as an antiknock additive in gasoline. Lead consumed for these two purposes in the United States in 1971 accounted for almost 65 per cent of total lead consumption. Other uses for lead are for solders, type metals, bearing metals and pigments. The metal is also used extensively for cable sheathing and in the manufacture of ammunition and collapsible tubes, caulking materials, corrosive-liquid containers, lead-base babbitts, and plumbing equipment such as pipes, drains and bends.

Because of its unique sound control characteristics, there is an expanding use for lead in sound attenuation where the biggest potentials seem to be in overceiling liners, doors, partition panels and removable walls in both commercial and residential construction. In the allied field of vibration isolation, lead-asbestos antivibration pads now are being used widely in foundations for office buildings, hotels and apartments exposed to severe vibration from nearby trains, subways or heavy haulage vehicles. Because of its sound control qualities lead is also used in the mounting of various types of equipment, including air-conditioning systems, printing presses and commercial laundry machines.

Miscellaneous uses include automotive wheel weights, ship ballast, roofing systems, sprayed lead coatings, terne steel and various alloys, and as lead-ferrite for permanent magnets in small electric motors. Relatively new uses are for leaded-porcelain enamel in coating aluminum and for radiation shielding against gamma rays in nuclear power reactors, nuclear-powered merchant 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 antifouling paints, wood and cotton preservatives, lubricant-oil additives, polyurethane foam catalysts, molluscicides, antibacterial agents, rodent repellents and rot-resistant textiles. Research programs carried out to consider the antiwear characteristics of organolead compounds in oil lubricants





Principal mine producers

(numbers refer to numbers on map)

1. American Smelting and Refining Company (Buchans Unit)
2. Dresser Minerals, Division of Dresser Industries, Inc.
3. Brunswick Mining and Smelting Corporation Limited (Nos. 12 and 6 mines)
   Heath Steele Mines Limited
   Nigadoo River Mines Limited
4. D'Estrie Mining Company Ltd.
   Sullivan Mining Group Ltd., Cupra Division
5. Manitou-Barvue Mines Limited
6. Ecstall Mining Limited
7. Big Nama Creek Mines Limited
   Noranda Mines Limited, Geco Division
   Willroy Mines Limited
8. Hudson Bay Mining and Smelting Co., Limited (Chisel Lake mine)
9. Reeves MacDonald Mines Limited (Reeves and Annex mines)
10. Cominco Ltd. (Sullivan and Bluebell mines)
11. Copperline Mines Ltd. (Ruth-Vermont mine)
    Kam-Kotia Mines Limited (Silmonac mine)
12. Teck Corporation Limited (Beaverdell mine)
13. Western Mines Limited
14. Venus Mines Ltd.
15. Anvil Mining Corporation Limited
16. United Keno Hill Mines Limited
17. Pine Point Mines Limited

Primary reduction plants

18. Brunswick Mining and Smelting Corporation Limited, Smelting Division (formerly East Coast Smelting and Chemical Company Limited)
19. Cominco Ltd.

Table 7. United States consumption of lead by end-use, 1970-71

	1970	1971p
	(tons)	
Storage batteries	593,453	625,259
Gasoline antiknock additives	278,505	264,240
Solder, type metal, terne metal and bearing metals	111,549	99,177
Ammunition and collapsible tubes	83,639	96,443
Pigments	98,736	87,397
Cable sheathing	50,772	51,682
Sheet and pipe	38,938	39,130
Caulking	34,608	26,268
Miscellaneous	70,352	56,795
Total reported[1]	1,360,552	1,346,391
Estimated undistributed consumption	–	46,000
Grand total	1,360,552	1,392,391

Source: United States Department of the Interior, Bureau of Mines Mineral Industry Surveys, Lead Industry in December 1971.
[1]Includes lead content of scrap used directly in fabricated products.
pPreliminary; – Nil.

indicate that the use of lead in the lubricating oil market in the United States could reach a potential of over 35,000 tons annually.

Refined lead is marketed in several grades that vary mainly according to the content of impurities, which include silver, copper, arsenic, antimony, tin, zinc, iron and bismuth. The three principal grades are: corroding (99.94 per cent), chemical (99.90 per cent) and common desilverized (99.85 per cent). The corroding grade has the highest purity and is used chiefly in the manufacture of pigments, battery oxides and tetraethyl lead. Common lead finds its greatest use in industrial and home construction. Chemical lead possesses superior creep and corrosion resistance and is ideally suited for cable sheathing. Common and corroding lead both sell for the same price but chemical commands a premium above the other two grades.

Prices

At the beginning of 1971, the Canadian price of lead, fob Toronto and Montreal, dropped from 14.5 to 13.5 cents a pound, and this price obtained for the rest of the year. The United States price for common lead, fob New York, was 13.5 cents a pound from the beginning of 1971 until June 23 when a dual price of 14-14.5 cents was established. On December 9 the pricing system was altered when a new dual price of 14.0-14.3 cents a pound was established based on delivery anywhere in the United States. The price remained at this level for the rest of the year. Under the new economic measures announced by President Nixon on August 15, 1971 a ceiling price of 16.5 cents a pound was placed on common lead (New York price) produced in the United Sates. This ceiling price became effective August 16, 1971 and at year-end it had still not been lifted. On the London Metal Exchange (LME), the settlement and cash sellers' price showed a slightly rising trend from January until April 1971, after which the trend was almost continuously downward. The high price for the year was £114.50 a metric ton (12.6 cents a pound Can.) on March 4. A low of £85.00 (9.6 cents Can.) was reached on November 22.

Tariffs

Canada

Item No.		British Preferential	Most Favoured Nation	General
32900-1	Ores of metals, not otherwise provided for	free	free	free
33700-1	Lead, old, scrap, pig and block, per lb	free	free	1¢
33800-1	Lead, in bars and in sheets	5%	5%	25%

United States

Item No.	Effective December 20, 1971	Noncommunist Countries (¢ per lb)	Designated Communist Countries (¢ per lb)
602.10	All lead-bearing ores, on lead content	0.75	1.5

Tariffs (Cont'd)

Item No.		Noncommunist Countries	Designated Communist Countries
		(¢ per lb)	(¢ per lb)
	Unwrought lead		
624.02	Lead bullion, on 99.6% of lead content	1.0625	2.125
624.03	Other, on lead content		
624.04	Lead waste and scrap, on 99.6% of lead content		

Sources: The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa. Tariff Schedules of the United States, Annotated (1972) T.C. Publication 452.

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, strictly speaking it should refer only to calcined limestone (quicklime) and its secondary products, slaked lime and hydrated lime. The former is the product of mixing quicklime and water, the latter is slaked lime dried and possibly reground.

Calcination is accomplished in kilns of various types but essentially those of vertical or rotary design are used, having over the years incorporated many adaptations to the standard designs. Of comparitively recent design are the rotary hearth, travelling grate, fluo-solid and inclined vibratory types.

Canadian industry and developments

Lime plants have been established near urban and industrial centres in Canada where there are large reserves of suitable limestone 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 92 per cent of Canada's total lime output in 1971, with Ontario contributing two thirds 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 1971 in Nova Scotia, Prince Edward Island, Saskatchewan and British Columbia, the needs in each of these provinces being supplied from plants in neighbouring provinces or states.

During 1971, 18 companies operated a total of 23 lime plants in Canada: 1 in Newfoundland, 1 in New Brunswick, 4 in Quebec, 10 in Ontario, 3 in Manitoba, and 4 in Alberta. A total of 86 kilns was available – 28 rotary, 55 vertical, 1 vibratory-grate and 2 rotary-grate. Lime production in 1971 was 1,519,000 tons excluding some captive production such as that from pulp and paper plants that burn sludge to recover lime for reuse in the causticization operation, and that produced by a large iron and steel complex for its own use.

Table 1. Canada, lime production and trade, 1970-71

	1970		1971[p]	
	(short tons)	($)	(short tons)	($)
Production[1]				
By type				
Quicklime	1,401,008	16,338,737	1,274,000[e]	. .
Hydrated lime	246,946	4,736,129	245,000[e]	. .
Total	1,647,954	21,074,866	1,519,000	19,050,000
By province				
Ontario	1,163,675	13,810,022	1,080,000	12,825,000
Quebec	345,398	4,641,930	293,000	3,500,000
Alberta	91,397	1,786,109	95,000	1,825,000
Manitoba	47,484	836,805	51,000	900,000
Total	1,647,954	21,074,866	1,519,000	19,050,000
Imports				
Quick and hydrated				
United States	33,704	762,000	26,293	677,000
France	27	13,000	28	11,000
Britain	54	3,000	124	4,000
Total	33,785	778,000	26,445	692,000
Exports				
Quick and hydrated				
United States	199,174	2,505,000	282,842	3,917,000
Guyana	1,023	13,000	500	9,000
Bermuda	295	6,000	362	9,000
Panama	82	2,000	19	1,000
Other countries	40	1,000	15	1,000
Total	200,614	2,527,000	283,738	3,937,000

Source: Statistics Canada.
[1] Producers' shipments and quantities used by producers. In 1970 distribution of shipments was as follows: shipped 1,078,000 st; used 570,000 st; total 1,648,000 st.
. . Not available. [p]Preliminary; [e]Estimated.

Atlantic provinces. At Aguathuna, near Stephenville on the west coast of Newfoundland, Sea Mining Corporation Limited produced lime from a hard, dense, grey, high-calcium limestone of Middle Ordovician age during 1970 but did not report production during 1971. The plant was designed to produce magnesium hydroxide from seawater and lime production was to be used captively in the process. Sales were made in 1969 when a market developed in the waste neutralization field on the island's east coast. This market is now supplied from Quebec-based lime producers.

Havelock Lime Works Ltd. began production of a high-calcium quicklime early in 1971, utilizing a newly installed, 100 tpd rotary kiln at the company's quarry site at Havelock, New Brunswick. Markets currently are limited to the mineral processing operations and to the pulp and paper industries mainly within the province. 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.

Quebec. At Joliette, Domtar Chemicals Limited, Lime Division, produced quicklime and hydrated lime from a high-calcium Trenton limestone for the steel and pulp and paper industries. Shipments were made to Maritime consumers as well as to Quebec and Ontario. A new hydrating section under construction during the past year was put into operation in early 1970.

Dominion Lime Ltd. produced high-calcium quicklime and hydrated lime from Silurian limestone at Lime Ridge, near Sherbrooke. Markets included the

Table 2. Canada, lime production, trade and apparent consumption, 1962-71

(short tons)

	Production[1]					
	Quick	Hydrated	Total	Imports	Exports	Apparent Consumption[2]
1962	1,190,848	233,611	1,424,459	36,115	71,583	1,388,991
1963	1,204,824	245,907	1,450,731	44,291	98,084	1,396,938
1964	1,249,394	291,333	1,540,727	20,791	106,343	1,455,175
1965	1,340,386	280,018	1,620,404	25,334	239,334	1,406,404
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*p*	1,274,000*e*	245,000*e*	1,519,000	26,445	283,738	1,261,707

Source: Statistics Canada.
[1]Producers' shipments and quantities used by producers. [2]Production plus imports less exports.
*e*Estimated; *p*Preliminary.

steel, pulp and paper, construction and agricultural industries.

A high-calcium limestone of the Beekmantown Formation of Ordovician age 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, containing less than 2 per cent silica and 0.015 per cent phosphorous, 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, operated a limestone quarry and a lime plant at Beachville. The high-calcium limestone was mined, crushed, screened and used primarily as feed to the lime plant which has both vertical and rotary kilns. A new rotary kiln was put on stream in 1970, doubling plant capacity. At Hespeler, Domtar produced lime, crushed stone and agricultural limestone. The lime plant has vertical kilns and produces high-quality, white quicklime. Both plants also produced hydrated lime.

For many years Cyanamid of Canada Limited operated a quarry at Beachville to supply chemical-grade limestone to the company's lime plant at Niagara Falls where a battery of seven rotary kilns produced high-calcium lime for the manufacture of calcium carbide. In 1957 a rotary-kiln lime plant was built at Beachville and in 1967 a calcimatic kiln was installed; it was made operative during 1968. Lime manufacture accounts for about half the limestone production, the remainder being used for open-hearth and blast furnace flux, for portland cement manufacture and as a pulverized stone.

Through a subsidiary, Chemical Lime Limited, The Steel Company of Canada, Limited at Hamilton was supplied with flux stone and with 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 tpd 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 produced a dolomitic lime near Guelph. Bonnechere Lime Limited, which operated kilns at Carleton Place and at 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.

Western provinces. The Winnipeg Supply and Fuel Company, Limited operates a quarry and lime plant at Spearhill, Manitoba, producing a white, high-calcium lime. Early in 1968 the company closed its lime plant at Stonewall, where a second quarry is

Table 3. Canadian lime industry, 1971

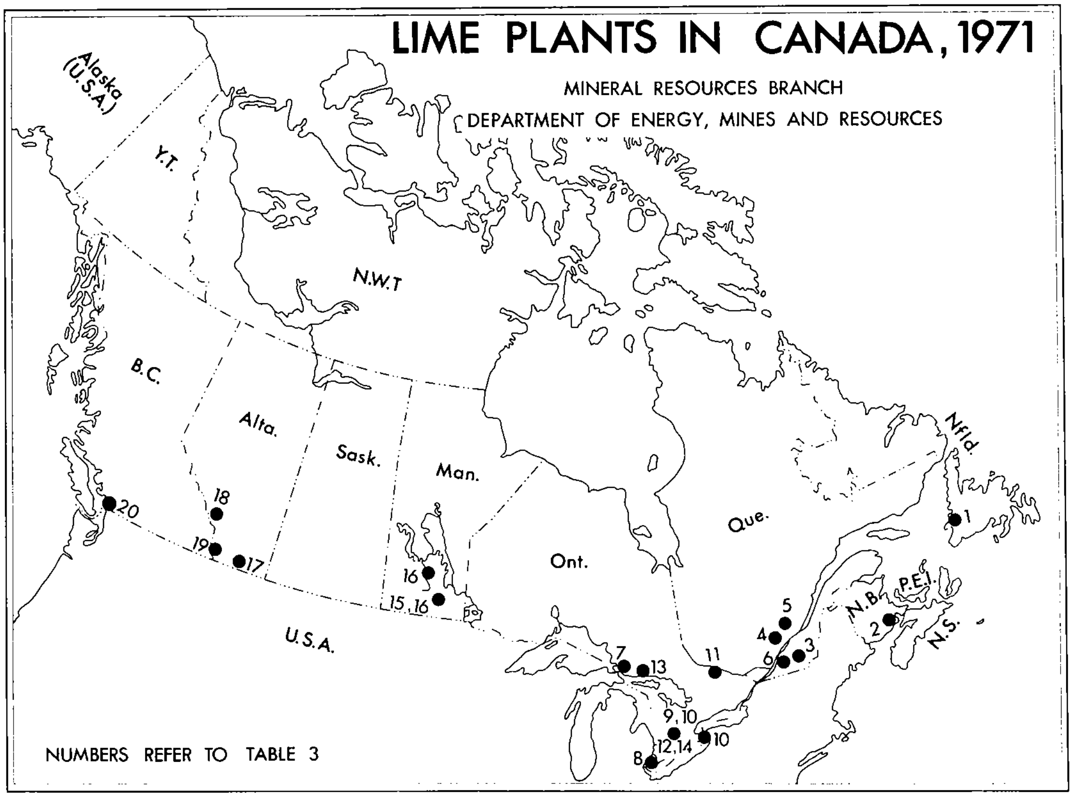
Company	Plant Location	Type of Quicklime
Newfoundland		
1. Sea Mining Corporation Limited	Aguathuna	High-calcium[4]
New Brunswick		
2. Havelock Lime Works Ltd.	Havelock	High-calcium
Quebec		
3. Dominion Lime Ltd.	Lime Ridge	High-calcium[4]
4. Domtar Chemicals Limited	Joliette	High-calcium[4]
5. Gulf Oil Canada Limited Shawinigan Chemicals Division[3]	Shawinigan	High-calcium[4]
6. Quebec Sugar Refinery[3]	St-Hilaire	High-calcium
Ontario		
7. The Algoma Steel Corporation, Limited[3]	Sault Ste. Marie	High-calcium
8. Allied Chemical Canada, Ltd.[3]	Amherstburg	High-calcium
9. Canadian Gypsum Company, Limited	Guelph	Dolomitic[4]
10. Cyanamid of Canada Limited	Beachville	High-calcium
	Niagara Falls	High-calcium
11. Chromasco Corporation Limited[3]	Haley	Dolomitic
12. Domtar Chemicals Limited	Beachville	High-calcium[4]
	Hespeler	Dolomitic[4]
13. Reiss Lime Company of Canada, Limited	Spragge	High-calcium
14. The Steel Company of Canada, Limited	Ingersoll	High-calcium
Manitoba		
15. The Manitoba Sugar Company, Limited[3]	Fort Garry	High-calcium
16. The Winnipeg Supply and Fuel Company, Limited	Spearhill	High-calcium
	Fort Whyte	High-calcium and dolomitic
Alberta		
17. Canadian Sugar Factories Limited[3]	Picture Butte	High-calcium
	Taber	High-calcium
18. Steel Brothers Canada Ltd.[1]	Kananaskis	High-calcium[4]
19. Summit Lime Works Limited	Hazell	High-calcium
British Columbia		
20. Texada Lime Ltd.[2]	Fort Langley	High-calcium

[1]New rotary kiln installed during 1971. [2]Lime plant under construction in 1971. [3]Production for captive use. [4]Hydrated lime produced also.

operated, and opened a modern lime manufacturing facility at Fort Whyte, a suburb of Winnipeg. Limestone is trucked to Fort Whyte where conventional processing equipment is used in conjunction with a vibratory-grate calciner, which offers maximum control of the calcining operation. Quicklime was supplied to chemical, metallurgical and construction industries and limestone was supplied to The Manitoba Sugar Company, Limited, during 1971.

Steel Brothers Canada Ltd. put a new rotary-kiln lime plant into operation early in 1968 at Kananaskis to replace the vertical, hanging kilns operated for many years. Limestone was quarried about 7 miles west of the plant site to provide kiln feed for the production of quicklime and hydrated lime. During 1971 construction progressed on the installation of a second rotary kiln which went on stream early in 1972. The new facility will double the production capacity of the plant.

Summit Lime Works Limited, near Crowsnest, produced high-calcium limestone for use at sugar refineries, dolomitic and high-calcium stone for metal-



lurgical use, 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 tpd. Limestone will be barged from Texada Island and the product – a high-calcium quicklime – will be 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 were responsible for the design and development of the project and will continue to supply management.

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. It is likely that the rate of increase will level during the next year or so. The addition of hydrated lime in the pelletizing of iron ore concentrates has resulted in a stronger, more stable pellet and could develop as a substantial market for lime.

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 general decline in this industry and in the chemicals industry during early 1971 has meant a corresponding loss of market for lime.

The uranium industry uses lime to control hydrogen-iron 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.

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. Research being done on the removal of sulphur from hydrocarbon

Table 4. Canada, consumption of lime, quick and hydrated, 1969-70

(producers' shipments and quantities used by producers, by use)

	1969		1970	
	(short tons)	($000)	(short tons)	($000)
Chemical and Metallurgical				
Iron and steel plants	354,162	4,223	376,274	4,853
Pulp mills	176,048	2,443	110,690	1,607
Nonferrous smelters	71,116	719	87,002	1,329
Sugar refineries	32,447	696	28,929	669
Cyanide and flotation mills	79,106	870	71,268	1,022
Water and sewage treatment	36,807	584	28,116	454
Other industrial[1]	674,121	6,305	743,810	7,742
Construction				
Finishing lime	63,896	1,621	50,027	1,405
Mason's lime	19,685	361	17,174	329
Sand-lime brick	13,685	109	6,564	98
Agricultural	18,679	184	15,253	291
Road stabilization	8,210	92	7,604	85
Other uses	86,900	1,032	105,243	1,191
Total	1,634,862	19,239	1,647,954	21,075

Source: Statistics Canada.
[1]Includes uranium plants, glass works, fertilizer plants, tanneries and other miscellaneous industrial uses.

Table 5. World production of quicklime and hydrated lime, including dead-burned dolomite sold or used 1969-70

Country	1969	1970[p]
	(thousand short tons)	
U.S.S.R.	23,524	23,700
United States	20,209	19,747
West Germany	11,758	11,813
Japan	4,657	10,110
Italy	6,388	6,400
France	4,615	4,650
Poland	2,456	3,875
Belgium	3,326	3,164
East Germany	2,770	2,755
Czechoslovakia[e]	2,535	2,535
Romania	2,114	2,200
Brazil[e]	1,800	1,800
Canada	1,635	1,648
Other countries	11,280	11,454
Total	99,067	105,851

Sources: U.S. Bureau of Mines, *Minerals Yearbook*, Preprint 1970; and Statistics Canada.
[p]Preliminary; [e]Estimated.

fuels includes the formation of calcium sulphide on a fluidized bed of lime followed by the burning of sulphur-free gas. Lime is effective, inexpensive, can be regenerated and the emission of SO_2 to atmosphere is controlled.

Soil stabilization, especially for highways, offers a potential market for lime. However, all soils are not of the physical and chemical characteristics which 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.

Production of lime-silica bricks, blocks and slabs has not been as popular in Canada as in European countries. These lightweight, cellular, insulating masonry forms have many features attractive to the building construction industry.

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. 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.

Canada is a net exporter of lime.

Prices

Canadian lime prices quoted in Canadian Chemical Processing of December 1971

Lime, carloads, fob works, bulk, per ton	($)
Ontario, quicklime	14.50
Alberta, quicklime	20.50
Ontario, hydrated	15
Alberta, hydrated	21

Tariffs

Canada

Item No.		British Prefer-ential	Most Favoured Nation	General
29010-1	Lime	free	free	25%

United States

Item No.		On and after Jan. 1, 1971	On and After Jan. 1, 1972
512.11	Lime, hydrated	5¢ per 100 lb incl. weight of container	free
512.14	Lime, other	5¢ per 100 lb	free

Sources: The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa. Tariff Schedules of the United States (Annotated), 1971, TC Publication 344.

Magnesium

D. G. SCHELL

Magnesium is a commonly occurring element, being even more abundant than iron or aluminum. It is found in seawater, brines and evaporite deposits, also in such minerals as dolomite, magnesite and brucite.

The metal is produced by two basic processes: by electrolysis of magnesium chloride derived from seawater and brines; and by high-temperature reduction of magnesium ores such as dolomite or magnesite. All Canadian production is by the latter process.

Canadian industry

The only Canadian producer of primary magnesium is Chromasco Corporation Limited (formerly Dominion Magnesium Limited). This company has operated a mine and smelter at Haley, Ontario, 50 miles west of Ottawa, since 1942. A high-quality 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 Pidgeon process, dolime is mixed with ferrosilicon and some fluorite and charged in batches into retorts which are externally heated in natural gas or electric furnaces. Under vacuum and at high temperature, the magnesium content is reduced and accumulates as crystalline rings known as 'crowns' in the water-cooled head sections of the retorts. The plant has an annual capacity of 12,000 short tons of magnesium metal, but operated at only about 60 per cent of capacity in 1971. A minor amount of this furnace capacity was used in the production of calcium.

The company produces 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 remelt or extrusion ingot is produced to all specifications. Other magnesium products include master alloys, rods, bars, wire and structural shapes.

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 mainly 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 particularly suited to chemical laboratory use, and as a reducing agent for uranium, zirconium, titanium and beryllium or similar applications where close control of impurities is necessary.

Production of magnesium in 1971, according to a preliminary report by Statistics Canada (see Table 1), was 7,252 short tons, a substantial decrease of 30 per cent from the previous year. This reduction was due to lack of markets. Although domestic demand increased, this positive factor was more than counterbalanced by drastically curtailed exports.

Domestic consumption of magnesium was 6,276 tons in 1971, a 27 per cent increase over the 4,937 tons consumed in 1970 (see Table 2). However, the 1970 figure was significantly lower than those of the two immediately prior years. As shown in Table 3, most of the increase that took place in 1971 was caused by greater use of magnesium in aluminum alloys and in magnesium castings. Aluminum alloys continued to be the largest single outlet for magnesium.

Imports of magnesium metal and alloys amounted to 1,979 tons in 1971, a decline of almost 14 per cent from 1970. Practically all imports in 1971 were from the United States. Exports, at 2,917 tons, suffered a severe reduction of 62 per cent, compared with 1970. Low-priced magnesium from Russia displaced much of Canada's traditional export market in Europe. Exports of magnesium metal enter the United States duty-free

Table 1. Canada, magnesium production and trade, 1970-71

	1970		1971p	
	(short tons)	($)	(short tons)	($)
Production[1] (metal)	10,353	7,140,807	7,252	5,205,000
Imports				
Magnesium metal				
United States	1,478	1,128,000	1,827	1,458,000
U.S.S.R.	550	348,0G0	–	–
Britian	8	25,000	–	–
Total	2,036	1,501,000	1,827	1,458,000
Magnesium alloys				
United States	222	596,000	119	267,000
Britain	34	80,000	33	81,000
Total	256	676,000	152	348,000
Exports				
Magnesium metal				
United States	1,407	1,104,000	950	821,000
Britain	1,986	1,369,000	811	560,000
Mexico	277	200,000	221	143,000
Hungary	177	113,000	173	120,000
France	1,136	806,000	155	111,000
India	7	5,000	122	100,000
Argentina	238	171,000	138	97,000
Switzerland	369	270,000	110	78,000
Brazil	22	15,000	50	52,000
Israel	8	12,000	35	38,000
Other countries	2,042	1,497,000	152	107,000
Total	7,669	5,562,000	2,917	2,227,000

Source: Statistics Canada.
[1]Magnesium metal, in all forms, and in magnesium alloys produced for shipment, less remelt.
pPreliminary; – Nil.

under the Canada-United States Defence Production Sharing Program, but this program recently has operated on a reduced scale. Although the United States duty on magnesium metal was reduced from 28 per cent to 24 per cent on January 1, 1971, only in certain highly pure items can the Canadian product find a market in the United States except under the above-mentioned program. A further reduction in the United States import duty on magnesium to 20 per cent effective January 1, 1972, in accordance with the Kennedy Round of trade negotiations under the General Agreement on Tariffs and Trade, is expected to be insufficient to enhance Canadian exports. The comparable Canadian tariff is 5 per cent.

World industry

World production of primary magnesium in 1971 was 253,700 tons, as shown in Table 4, less than 4 per cent above the previous year. The United States retained its dominant position, accounting for almost half of world production. Communist countries (mainly Russia) and Norway were the next largest producers, followed by Japan, Canada and Italy. Table 5 shows estimated primary capacity. Secondary magnesium adds to the effective supply in some countries, notably the United States (11,800 tons), Japan (9,200 tons) and West Germany (4,600 tons), based on 1970 statistics, the latest available.

A further source of magnesium metal is the General Services Administration stockpile in the United States. In 1971 only 710 tons were sold from this stockpile, a vast reduction from the 15,400 tons sold in 1970. Some 98,000 tons remained for disposal at the end of 1971.

During the decade of the 1960's there were frequent periods of magnesium shortage. Future increases in capacity were planned by several companies. However, growth of demand for the metal has slowed. Shipments of primary magnesium in the United States

Table 2. Canada, magnesium production, trade and consumption, 1961-71

	Production,[1] metal	Imports		Exports, Metal		Consumption,[2] Metal
		Alloys	Metal			
	(st)	(st)	(st)	(st)	($)	(st)
1961	7,635	..	..	..	3,608,523	2,776
1962	8,816	..	..	..	3,967,932	3,614
1963	8,095	..	..	..	3,676,725	3,641
1964	9,353	187	1,594	..	3,951,386	3,762
1965	10,108	166	1,641	..	4,456,255	4,499^r
1966	6,723	330	3,011	..	3,452,000	5,137^r
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^p	7,252	152	1,827	2,917	2,227,000	6,276

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; ^{r}Revised.

Table 3. Canada, consumption of magnesium, 1961 and 1967-71

	1961	1967	1968	1969	1970	1971
	(short tons)					
Castings[1]	395	631	601^r	793	850	1,316
Extrusions[2]	251	659	926^r	529	474	375
Aluminum alloys	1,604	3,253	3,713	3,710	3,123	3,972
Other uses[3]	526	511	414^r	640	490	613
Total	2,776	5,054	5,654	5,672	4,937	6,276

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.
^{r}Revised. ^{p}Preliminary.

in 1971 were 120,200 tons, only 1,500 tons more than in 1970. World supply and demand essentially remained in balance in 1971, but planned expansion of production capacity forebodes an excess of supply.

Threatened with overcapacity, some projects were delayed or cancelled. Completion of Dow Chemical Company's plant under construction at Dallesport, Washington, was deferred until 1975. It will have an ultimate capacity of 48,000 tons a year. A joint project of Norsk Hydro and Salzdetfurth in West Germany to produce 30,000 tons a year has been postponed indefinitely. American Magnesium Company's plant at Snyder, Texas, was shut down temporarily because of excessive air pollution. Although the full capacity of this plant was to be 30,000 tons a year, it was only producing about 5,000 tons a year at the time of closure. On the other hand, NL Industries Inc. (formerly known as National Lead Company) proceeded with its 45,000-ton-a-year plant at Rowley, Utah, and initial sales are anticipated in 1972. This facility produces magnesium from Great Salt Lake brine, a highly concentrated source of magnesium chloride; chlorine is marketed as a valuable byproduct. The Aluminum Company of America plans a plant at Addy, Washington to produce 30,000 tons a year, but production is not scheduled until 1974. Norsk Hydro added 7,000 tons of annual production capacity to its Porsgrund, Norway facility and another 8,000 tons a year is planned for 1972. Société Générale du Magnésium of France raised its annual capacity by 2,000 tons and a new 4,000-ton-a-year plant in Yugoslavia will open in 1973.

Table 4. World primary magnesium production

	1961	1970	1971[e]
	(thousand short tons)		
United States	40.8	112.0	123.5[1]
U.S.S.R.	34.0	. .	. .
Norway	16.0	39.0	39.0
Japan	2.5	11.4	12.0
Canada	7.6	10.4	7.2
Italy	6.2	7.2	7.0
France	2.3	. .	. .
West Germany	0.4	. .	. .
Britain	4.2	. .	. .
People's Republic of China	1.1	. .	. .
Other noncommunist countries	–	8.0	9.0
Communist countries	–	56.1	56.0
Total	115.1	244.1	253.7

Sources: For Canada, Statistics Canada. For other countries, 1961: U.S. Bureau of Mines *Minerals Yearbook 1962*; 1970 and 1971: U.S. Bureau of Mines, Commodity Data Summaries, January 1972.
[e]Estimated; . . Not available; – Nil.
[1]Mineral Industry Surveys, U.S. Bureau of Mines.

Uses

The major use of magnesium is in aluminum alloys (40 per cent of total industrial use). Other forms of manufacture and uses are: mill products (15 per cent), sand and die castings (15 per cent), powder (10 per cent), titanium reduction (4 per cent) and miscellaneous nonstructural uses (16 per cent). Some European automobiles contain considerable magnesium castings but the metal has been unable to gain a foothold in North American automobile manufacturing, perhaps because of high metal loss in processing, rapid solidification in the die, causing rejects, and the need of surface protection (as opposed to aluminum and plastics). Magnesium castings are used extensively in power lawnmowers, chain saws, typewriters, calculators and electronic equipment. Because of its high strength-to-weight ratio, magnesium is used in structural applications, i.e., those which involve load-carrying components. Typical uses are in aircraft, particularly helicopters, missiles and space exploration vehicles, as well as luggage frames and materials-handling equipment, such as gravity conveyors and hand trucks. However, structural applications are declining in importance compared with nonstructural uses, partly because of decreasing emphasis on military and aerospace programs. Nonstructural applications now account for 75 per cent of the use 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 nonstructural uses of magnesium are as an alloy for ductile iron, as a reducing agent in production of titanium, cathodic protection, and in the chemical industry for Grignard reagents and as an antiknock fuel additive. A promising new market for magnesium is for dry cell batteries. This application has progressed to the point where the United States armed forces use magnesium back-pack batteries for their communication sets.

Prices

The Canadian domestic quotation at the end of 1971 for standard alloys was 35 cents a pound, fob Haley, Ont., a rise of 1 cent during the year. United States magnesium prices, in U.S. currency, quoted in *Metals Week* of December 20, 1971 were as follows:

Magnesium metal, per lb, 10,000-lb lots, pig, ingot
pig, 99.8% 36.25¢
notched ingot 37¢

Magnesium die-casting alloy, AZ91B ingot, per lb 31.5¢

Table 5. Estimated world primary magnesium capacity, 1971

	Company Name	Location	Annual Capacity (tons)
Canada	Chromasco Corporation Limited	Haley, Ontario	12,000(F)
France	Société Générale du Magnésium	Marignac	9,000(F)
Italy	S.A. Italiana per il Magnesio e Leghe di Magnesio, Milan	Bolzano	7,700(F)
Japan	Furukawa Magnesium Company	Oyama	7,300(F)
	Ube Kosan KK	Ube	6,600(F)
Norway	Norsk Hydro-Elektrisk Kvaelsto-faktieselskab	Heroya near Porsgrund	47,000(E)
United States	American Magnesium Company	Snyder, Texas	5,000(E)
	The Dow Chemical Company	Freeport, Texas	120,000(E)
U.S.S.R.	Various		50,000

Process: F – Ferrosilicon; E – Electrolytic.
Sources: Société française de minerais et métaux, American Bureau of Metal Statistics, and various others.

Tariffs

Canada

Item No.		British Preferential	Most Favoured Nation	General
		(%)	(%)	(%)
35105–1	Magnesium metal, not including alloys, in lumps, powders, ingots, or blocks	5	5	25
34910–1	Alloys of magnesium, ingots pigs, sheets, plates, strips, bars, rods and tubes			
34915–1	Magnesium scrap	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 1972)	free	free	25
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 31 January 1972)			

United States

		On and After January 1	
		1971	1972
628.55	Magnesium, unwrought, other than alloys; and waste and scrap (duty on waste and scrap suspended to June 30, 1973)	24%	20%
628.57	Magnesium, unwrought alloys, per lb on Mg content	9.5¢ + 4.5%	8¢ + 4%
628.59	Magnesium metal, wrought, per lb on Mg content	8¢ + 4%	6.5¢ + 3.5%

Sources: The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa. Tariff Schedules of the United States, Annotated (1971) TC Publication 344.

Manganese

D.D. BROWN

Canada imported 110,885 short tons of manganese (Mn content) in ores and concentrates valued at $5,973,000 in 1971 compared with 126,823 tons valued at $5,968,000 in 1970. Brazil has become Canada's principal source of manganese supplying 41,372 tons in 1970 and 54,000 tons in 1971. Imports of ferromanganese, silicomanganese and spiegeleisen were 21,558 tons valued at $2,971,000 compared with 19,721 tons valued at $2,602,000 in 1970.

Manganese ores were in abundant supply on world markets in 1971. Published prices for manganese ore containing 48 per cent manganese were 59 to 62 cents, nominal, per long-ton unit, c.i.f. eastern United States ports, in the early part of the year. From March to the end of the year prices were higher at 63 to 68 cents, nominal, per long-ton unit of clean 48 per cent Mn ore. The newer producers in Australia, Gabon and Brazil can readily expand their large, mechanized manganese production facilities to assure adequate supplies.

Canada does not produce manganese ore; minor amounts have been mined intermittently from small occurrences in Nova Scotia, New Brunswick and British Columbia. The known occurrences are too small or too low-grade to be of present economic importance.

World production and trade

World production of manganese ores at an estimated 20.5 million tons was not significantly changed from 1970. The U.S.S.R. continued to be the principal producer with an output of about 8 million tons. The Republic of South Africa, Brazil, India and Gabon each produced from 2.9 to 1.6 million tons in 1971 as listed in Table 3.

United States is the leading importer and consumer of manganese ores. The U.S. Bureau of Mines, Mineral Industry Surveys, reported imports of 1,914,264 tons and consumption of 2,047,238 tons in 1971. Leading suppliers were Brazil, Gabon, and the Republic of South Africa. United States imports of ferromanganese were 250,667 tons compared with 290,976 tons in 1970. United States consumption of ferromanganese was 880,712 tons in 1971.

Uses and specifications

The major use of manganese is in steel manufacture where it is used to remove sulphur, as a deoxidizer, and as an alloying constituent to improve the properties of strength, hardness and hardenability. The Hadfield or manganese steels, containing 10 to 14 per cent manganese, are noted for their ability to work-harden. The Brinell hardness of the metal is about 200 after heat treatment but steel-rail frogs have hardened in use to over 500 Brinell. Light blows of high velocity cause shallow deformation and hardening while heavy impacts produce deep hardening. Fine-grained manganese steels have unusual toughness and strength and are often used for making gears, spline shafts, axles, cylinders for compressed gas, crusher parts and many other products.

Major use distribution of manganese ore in the United States and Canada in 1970 was 99 per cent metallurgical and 1 per cent in the dry-cell battery and chemical industries.

The principal form in which manganese is used by the steel industry is ferromanganese, the most important of the ferroalloys used in steelmaking. The gross weight of ferromanganese used in Canada in 1970 (1969) was 82,356 (70,305) tons and of silicomanganese was 25,717 (20,789) tons; consumption of two other important ferroalloys, ferrosilicon and ferrochrome, was 55,728 (50,737) tons and 31,257 (25,035) tons respectively. Standard or high-carbon ferromanganese contains 74 to 82 per cent manganese, 7.5 per cent carbon and not over 1.25 per cent silicon, 0.35 per cent phosphorus or 0.05 per cent sulphur. Low-carbon ferromanganese is used when it is important to limit carbon entering the steel and is available in several grades containing 0.75 per cent or less carbon and 80 to 85 per cent manganese.

Table 1. Canada, manganese trade and consumption, 1970-71

	1970		1971^p	
	(short tons)	($)	(short tons)	($)
Imports				
Manganese, in ores and concentrates[1]				
Brazil	41,372	1,873,000	54,000	2,469,000
United States	10,178	1,003,000	6,775	938,000
Gabon	27,099	1,340,000	18,691	909,000
Republic of Zaire[2]	16,505	513,000	15,416	730,000
Ghana	15,086	570,000	9,903	603,000
U.S.S.R.	5,569	224,000	5,951	301,000
Japan	33	17,000	32	18,000
Mexico	66	7,000	117	5,000
Other countries	10,915	421,000	–	–
Total	126,823	5,968,000	110,885	5,973,000
Ferromanganese including spiegeleisen[3]				
South Africa	18,478	2,301,000	19,872	2,500,000
United States	1,021	257,000	1,548	407,000
West Germany	–	–	75	38,000
Japan	37	12,000	34	13,000
France	–	–	29	13,000
Norway	185	32,000	–	–
Total	19,721	2,602,000	21,558	2,971,000
Silicomanganese, including silico spiegeleisen[2]				
Norway	372	72,000	1,106	198,000
South Africa	387	67,000	560	72,000
United States	316	81,000	124	37,000
Total	1,075	220,000	1,790	307,000
Exports				
Ferromanganese[3]				
Venuezuela	–	–	225	59,000
Jamaica	–	–	146	29,000
United States	494	116,000	10	1,000
Britain	65	13,000	–	–
Columbia	3	1,000	–	–
Total	562	130,000	381	89,000
Consumption[3]				
Manganese ore				
Metallurgical grade	167,211	..	..	..
Battery and chemical grade	2,375	..	..	..
Total	169,586	..	..	..

Source: Statistics Canada.
[1]Mn content; [2]Changed from Democratic Republic of the Congo (Kinshasa) on October 27, 1971; [3]Gross weight.
[p]Preliminary; – Nil; .. Not available.

Table 2. Canada, manganese imports, exports and consumption, 1961-71

(gross weight, short tons)

	Imports			Exports	Consumption	
	Manganese Ore[1]	Ferromanganese Under 1% Silicon	Ferromanganese Over 1% Silicon	Ferro-manganese	Ore	Ferro-Manganese
1961	76,016	12,121	2,173	238	78,642	44,545
1962	90,725	14,986	2,726	136	85,410	52,284
1963	106,891	22,639	2,355	10	92,270	58,555
1964	62,813	21,830	1,744	3,359	138,959	66,203
1965	89,480	34,562	787	3,817	119,289	61,352
1966	184,103	49,118	1,931	5,722	152,536	68,360
1967	82,659	16,044	4,202	4,339	137,395	61,667
1968	69,209	27,941	1,344	1,018	124,904	71,470
1969	107,954	24,524	4,599	5,512	168,485	70,305
1970	126,823	19,721	1,075	562	169,586	82,356
1971^p	110,885	21,558	1,790	381	..	..

Source: Statistics Canada.
[1] From 1964, Mn content, prior years gross weight; ^{p}Preliminary; .. Not available.

Table 3. World production of manganese ores

(thousands of short tons)

Country	Per Cent Mn^e	1969	1970^p	1971^e	Country	Per Cent Mn^e	1969	1970^p	1971^e
U.S.S.R.	..	7,221	7,700^e	7,700	Morocco	35-53	144	124	120
Republic of					Italy	30-	58	55	
South Africa	30+	2,430	2,954	2,900	Botswana	30+	25	45	
Brazil	38-50	2,166	2,126	2,100	Bulgaria	30+	43	44^e	
India	32-53	1,637	1,820	1,700	Iran	35+	39	40	
Gabon	50-53	1,502	1,602	1,600	Zambia	35+	28	33^e	
China^e	30+	1,100	1,100	1,100	Thailand	40+	33	26	(500)
Australia	46	1,016	1,106	1,150	Chile	41-47	26	29	
Ghana	48+	367	447	450	Fiji	30-50	23	27	
Republic of					Ivory Coast	32-47	140	25	
Zaire	42+	343	382	390	Angola	30+	32	25	
Japan	30-43	332	299	300	Other				
Mexico	35+	158	302	300	countries[1]		161	163	
Hungary	30-	172	186	190	Total		19,196	20,654	20,500

Sources: U.S. Bureau of Mines, *Minerals Yearbook 1970;* 1971, author's estimate.
[1] Includes some 20 countries, each producing less than 35,000 tons a year. ^{e}Estimated; ^{p}Preliminary; . .Not available.

Minerals and sources

Manganese occurs in many minerals that are widely distributed in the earth's crust but very few are of economic importance. The most common sources of the element are the minerals pyrolusite (MnO_2) and psilomelane ($MnO_2H_2O{\cdot}K,Na,Ba$ variable). These minerals may be accompanied by other oxides of manganese such as wad or bog manganese, hausmannite (Mn_3O_4) and braunite ($3Mn_2O_3MnSiO_2$). The carbonate rhodocrosite ($MnCO_3$) and the silicate rhodonite ($MnSiO_3$) are not usually of commercial importance but may constitute the source of enriched oxide deposits when decomposed and reconcentrated.

World production of manganese comes almost entirely from oxides of the element. In contrast to the ores of many other metals, manganese ores are not always reduced to the metal but are used as chemicals and in batteries in the form of oxides. The term 'manganese ore' is usually applied only to ores containing over 35 per cent manganese. Ores with less than 35 per cent manganese are described as ferruginous manganese or manganiferous ores.

The U.S.S.R. with very large manganese reserves, is the leading world producer and is the only major industrial nation that is self-sufficient in manganese. Important manganese deposits are also found in the Republic of South Africa, India, Brazil, Gabon, Ghana, Guyana and China. Australia has become a major producer in recent years. Many other countries contribute to world production.

Table 4. Principal manganese additive materials

	Manganese	Silicon	Carbon
	(%)	(%)	(%)
Ferromanganese			
high-carbon			
(standard)	74-82	1.25 max.	7.5 max.
medium-carbon	74-85	1.50 max.	1.50 max.
low-carbon	80-85	7.00 max.	.75 max.
Silicomanganese	65-68	18-20 max.	1.5
Spiegeleisen	16-28	1.00-4.50	6.5
Electrolytic metal	99.87	0.025	0.004

Source: *E & MJ Metal and Mineral Markets*, November 1965.

Table 5. United States, consumption of manganese ferroalloys and metal, 1969-71

(short tons, gross weight)

	1969	1970	1971
Ferromanganese			
High-carbon	925,894	848,718	724,062
Medium- and low-carbon	125,888	127,086	126,650
Silicomanganese	150,013	136,328	119,857
Spiegeleisen	21,516	19,801	19,129
Manganese metal	21,966	17,183	25,429

Source: Mineral Industry Surveys, U.S. Bureau of Mines, Department of the Interior, Washington, D.C.

Metallurgical-grade manganese ore. Manganese ores having a manganese-iron ratio of 7 to 1 or more are preferred for making ferromanganese because it is possible to maintain a high productive capacity in the ferroalloy plant. High silica is undesirable because it increases the quantity of slag with attendant high loss of manganese. Since ores seldom have an ideal composition most ferromanganese producers use ores from more than one source and blend them to attain the specifications they require. Manganese ores imported by the United States in 1971 and used in producing ferromanganese, silicomanganese and manganese metal varied in grade from 35 per cent to 52 per cent manganese and averaged 49 per cent. General specifications for metallurgical-grade ore and the bases for price quotations call for 46 to 48 per cent manganese and maxima of 7 per cent iron, 8 per cent silica, 0.15 per cent phosphorus, 6 per cent alumina, and 1 per cent zinc. The ore should be in hard lumps of less than 4 inches and not more than 12 per cent should pass a 20 mesh screen. Representative analyses of manganese ores and concentrates from different sources are shown in Table 6.

Battery-grade manganese ore. Battery-grade manganese ores are subject to chemical and physical specifications but the principal requirement is a high manganese dioxide (MnO_2) content. Ores that are suitable for the manufacture of dry-cell batteries are usually suitable for metallurgical use but metallurgical ores are less frequently suitable for battery manufacture. Tests are carried out by making batteries from trial lots of ore and placing the batteries in test service. The composition of a battery-grade ore should generally be within the following limits:

	Per Cent
MnO_2	75-85
Total Mn	48-58
Absorbed moisture	3-5
Iron as Fe	0.2-3.0
Silicon as SiO_2	0.5-5.0
Other metallic impurities	0.1-0.2

Chemical grade manganese ore. Manufacturers of manganese chemicals use ores of various grades including high-grade ores and concentrates also suitable for metallurgical use. There are used to make manganese chemicals such as hydroquinone, potassium permanganate, sulphates, and chlorides for use in the welding rod, glass, dye, paint and varnish, fertilizer, pharmaceutical and photographic industries.

Manganese ores of various grades are used in the manufacture of electrolytic manganese metal and in the production of synthetic manganese dioxide for the metallurgical, chemical and battery industries.

Table 6. Representative analyses of manganese ores and concentrates

(per cent)

Country of Origin	Mn	Fe	SiO_2	Al_2O_3	P	Moist-ure	Ratio Mn/Fe
Ghana[1]	52	1.3	7.9	2.6	0.12	5.1	39.7
Ghana[1]	46	1.6	18.6	3.1	0.05	0.5	29.0
Guyana	39	7.2	14.2	19.3	0.07	0.4	5.4
Guyana	52	2.6	7.1	3.2	0.11	4.8	20.0
Egypt	51	6.9	1.4	.8	0.08	1.0	7.5
Egypt	49	8.2	2.2	1.0	0.08	0.7	6.0
Brazil (Amapa)[2]	50	4.1	2.7	6.0	0.07	4.5	12.3
Brazil (Urucum)	45	12.2	1.5	2.1	0.22	5.6	3.7
Mexico[3]	47	1.8	9.7	1.1	0.01	1.2	25.5
Gabon (Moanda)	50-52	2-4	1-3	5-7	0.09-0.013	..	..
Congo Republic (Kisenge)	49	2.4	7.1	4.5	0.13	..	..
Congo Republic (Kisenge)	50	2.4	5.9	5.8	0.11	..	..
Congo Republic (Kisenge)	50.5	2.4	4.6	4.5	0.14	..	..
India	49	6.3	9.0	1.6	0.14	3.5	7.1
India	40	15.7	2.3	6.0	0.03	1.3	2.5
Turkey	46	0.9	9.9	1.3	0.02	6.3	50.4
Republic of South Africa	40	16.2	2.3	6.1	0.03	0.4	2.5
South West Africa	47	5.6	12.2	1.4	0.04	0.9	8.5
Philippines	49	3.4	8.2	2.9	0.12	3.2	14.4
U.S.S.R. (Chiatura)[4]	53	1.2	..	2.0	0.17	7.5	44.2
U.S.S.R. (Nikopol)[5]	49	1.5	..	1.4	0.20	12.0	32.7

Source: Compiled from a survey of technical and trade publications.
[1] 12.5 to 13.5% CaO+MgO; [2] 0.18% As; [3] 0.25% As; 8.42% CaO and 1.38% BaO; [4] 0.15 to 1.6% CaO+MgO; [5] 1.1 to 2.3% CaO+MgO.
.. Not available.

Canadian suppliers and consumers

Union Carbide Canada Limited, Metals and Carbon Division, uses metallurgical grade ore to manufacture standard high-carbon ferromanganese, medium- and low-carbon ferromanganese and silicomanganese. Union Carbide will expand its alloy plant at Beauharnois, Quebec, with the installation of a new electric furnace having an annual production capacity of 80,000 tons a year of ferromanganese and silicomanganese in total. Completion of the new furnace is scheduled for mid-1973.

Chromium Mining & Smelting Corporation, Limited produces manganese alloys at its plant in Beauharnois, Quebec.

Imported eletrolytic manganese is used by Atlas Steel in the manufacture of low-carbon stainless steel. It is also used by the aluminum, magnesium and copper-alloy industries.

Among principal Canadian consumers of ferromanganese are—*in Nova Scotia:* Sydney Steel Corporation, Sydney; *in Quebec:* Atlas Steels Division of Rio Algom Mines Limited, Tracy, Dosco Steel Limited, Montreal; *in Ontario:* The Algom Steel Corporation, Limited, Sault Ste. Marie; Atlas Steels, Welland; Burlington Steel Division of Slater Steel Industries Limited, Hamilton; Dominion Foundries and Steel, Limited, Hamilton; The Steel Company of Canada, Limited, Hamilton.

Consumers of battery-grade ore are National Carbon Limited and Mallory Battery Company Limited, both of Toronto, and Ray-O-Vac Division of ESB Canada Limited, Winnipeg.

Prices

United States prices in U.S. currency, published by Metals Week of December 28, 1970, and December 20, 1971

	December 28, 1970	December 20, 1971
	(¢)	(¢)
Manganese ore, per long-ton unit (22.4 lb) c.i.f. U.S. ports, Mn content		
Min. 48% Mn (low impurities)	(N) 59-62	(N) 63-68
Min. 46% Mn	(N) 56-58	(N) 61-63
Ferromanganese, f.o.b. shipping point, freight equalized to nearest main producer, carload lots, lump, bulk per long ton of alloy		
	($)	($)
Standard 74-76% Mn	(N) 169.50	(N) 169.50
78% min. Mn	190.00	190.00
low phosphorous	(N) 220.00	(N) 220.00
Imported standard 74-76% Mn, delivered Pittsburgh, Chicago	(N) 180.00	(N) 176-178
	(¢)	(¢)
Medium-carbon, per lb. Mn	19.5	18.5-18.75
"MS" manganese, per lb. Mn	21.0	21.0
Low carbon, per lb. Mn		
0.10% C	30.5	30.5
0.30% C	30.5	29.5
0.75% C	30.5	30.5
Ferromanganese silicon, 0.05% C per lb. alloy	16.8	16.8
Ferromanganese briquettes, per lb. alloy	9.2	9.2
Manganese metal, electrolytic metal, 99.9%, per lb. Mn, boxed, f.o.b. shipping point		
Regular	33.25	33.25
Hydrogen-removed	33.25	33.25
4-5% N	34.25	34.25
6% N	36.25	36.25
Silicomanganese, per lb. of alloy, f.o.b. shipping point, freight equalized to nearest main producer, carload lots, lump, bulk		
12½-16% Si, 3% C	10.65	10.65
High-Mn, 15.5-17% Si.		
1.75-2.25% C	11.90	11.90
16-18½% Si, 2% C	10.65	10.65
18-21% Si, 1½% C	11.38	11.38
Briquettes	11.00	11.00

(N) Nominal.

Tariffs

Item No.		British Preferential	Most Favoured Nation	General
Canada			(¢)	(¢)
32900-1	Manganese ore	free	free	free
33504-1	Manganese oxide	free	free	free
35104-1	Electrolytic manganese metal	free	free	2070
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
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

Tariffs (Cont'd)

United States

		On and After Jan. 1, 1971	On and After Jan. 1, 1972
		(¢ per lb on Mn content)	
601.27	Manganese ore (duty temporarily suspended to end of June 1973)	0.15	0.12
607.35	Ferromanganese, not containing over 1% C	0.3 + 2.5%	0.3 + 2%
607.36	Ferromanganese, containing over 1% but not over 4% C	0.55	0.46
607.37	Ferromanganese containing over 4% C	0.35	0.3
632.32	Manganese metal, unwrought, waste and scrap (duty temporarily suspended on waste and scrap to end of June 1973)	1.5¢ per lb + 11% ad. val.	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, (1971) TC Publication 344.

Mercury

J.G. GEORGE

The Pinchi Lake mine, located some 30 miles north of Fort St. James, British Columbia, was again in 1971 the main source of Canada's mine output of mercury. Only minor quantities were derived from other producers in southern British Columbia. The Pinchi Lake mine, operated by Cominco Ltd., restarted operations in August 1968 with a mill with rated capacity of 800 short tons[1] of ore a day. In 1971, the mill processed only 248,000 tons of cinnabar ore compared with 390,000 tons in 1970. Production was restricted in 1971 to meet market requirements. Most of the ore was derived from underground operations with the remainder, about 26 per cent, coming from the open pits which operated during the summer months. Beneficiation of the ore consists in concentrating it by flotation, and then roasting the concentrate to produce a mercury vapour which in turn is cooled and condensed to produce liquid metallic mercury. The company's 1971 exploration program was successful, with reserves at year-end at its Pinchi Lake property exceeding those at December 31, 1970.

At its electronic materials plants at Trail, B.C., Cominco Ltd. also produces high-purity mercury metal with metallic impurities totalling ten parts per billion or less. This specialty metal product is manufactured mainly for specific applications in the electronics industry, such as advanced radiation detector materials.

Silverquick Development Co. (B.C.) Ltd. continued construction of a 500-ton-a-day concentrator at its mercury property near Gold Bridge in the Bridge River district of southern British Columbia. The property is still in the exploration and development stage and late in 1971 a surface diamond drill program was completed. In November 1970, proven ore reserves were estimated at 128,700 tons averaging 3.3 pounds of mercury per ton and indicated ore reserves 511,000 tons averaging 3.8 pounds of mercury per ton. On January 14, 1971, Highland Mercury Mines Limited entered into an agreement with Cominco Ltd. whereby further exploration and development of its mercury property near Pinchi Lake, in the Omineca Mining Division of British Columbia, would be carried out and financed by Cominco. The agreement provides for an expenditure of up to $100,000 over approximately three years ending December 1, 1973, with $25,000 to be spent in the first year.

Canadian imports of mercury metal in 1971, at 122,000 pounds, were lower than the 153,300 pounds imported in 1970. Statistics on Canadian production and exports of mercury are not available. Reported consumption in Canada in 1971 was 193,968 pounds, much lower than the 340,558 pounds consumed in 1970.

World review

Estimated world mine production of mercury in 1971 was 300,616 flasks[1], or about 16,300 flasks greater than in 1970. Spain and Italy together accounted for almost 37 per cent of the total output. The seven countries with the largest production, in declining order of output, were Spain, Russia, Italy, Mexico, People's Republic of China, United States and Yugoslavia.

[1]Wherever used in this review, the term 'ton' refers to the short ton of 2,000 pounds avoirdupois, unless otherwise stated.

[1]The flask containing 76 net pounds avoirdupois is used throughout this review.

Table 1. Canadian mercury production, trade and consumption, 1970-71

	1970		1971p	
	(pounds)	($)	(pounds)	($)
Production	..	..	..	..
Imports (metal)				
United States	22,300	127,000	81,700	342,000
Mexico	79,000	504,000	35,500	125,000
Spain	51,200	337,000	3,800	12,000
Britain	–	–	1,000	6,000
Sweden	800	19,000	–	–
Total	153,300	987,000	122,000	485,000
Consumption (metal)				
Heavy chemicals	326,550		181,913	
Electrical apparatus	10,461		10,426	
Gold recovery	1,155		921	
Miscellaneous	2,392		708	
Total	340,558		193,968	

Source: Statistics Canada.
pPreliminary; – Nil; . . Not available.

Table 2. Canadian mercury production, trade and consumption, 1962-71

	Production, Metal	Imports Metal	Imports Salts	Exports, Metal	Consumption, Metal
	(pounds)	(pounds)	($)	(pounds)	(pounds)
1962	–	245,059	3,838	..	135,291
1963	–	447,592	9,521	..	147,396
1964	5,548	293,900	..	..	208,304
1965	1,520	1,071,900	..	..	415,996
1966	–	404,600	..	..	171,588
1967	–	356,300	..	..	245,121
1968	..	197,900	..	..	327,939
1969	..	133,600	..	..	308,814
1970	..	153,300	..	..	340,558
1971p	..	122,000	..	..	193,968

Source: Statistics Canada.
pPreliminary; – Nil; . . Not available.

Mine output of mercury in the United States continued its decline in 1971, to 17,627 flasks, compared with 27,296 flasks in 1970. Production was derived from some 60 mines as against 79 mines in 1970; and at the end of 1971 only about 30 mines remained active. 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 1971 in the United States of primary, redistilled and secondary mercury was estimated at 52,475 flasks, a considerable reduction from the 61,503 flasks consumed in 1970.

The further decline in the use of mercury in the United States in 1971 was again attributed mainly to the problem of mercury pollution. The pollution factor became serious when fish caught in Lake St.

Table 3. World production of mercury

	1967	1970	1971[p]
		(flasks)	
Spain	49,227	45,543	67,528
U.S.S.R.[e]	45,000	48,000	50,000
Italy	48,066	44,382	42,671
Mexico[1]	14,417	30,265	30,000[e]
People's Republic of China[e]	20,000	20,000	20,000
United States	23,784	27,296	17,627
Yugoslavia	15,890	15,461	15,564
Turkey	4,147	8,592	9,500[e]
Algeria	. .	. .	7,136
Czechoslovakia	203	4,815	7,000[e]
Japan	4,617	5,170	5,700[e]
Philippines	2,611	4,648	4,800
Ireland	. .	1,304	2,000[e]
Peru	3,135	3,125	1,800[e]
Other countries[e]	976	25,715	19,290
Total	232,073	284,316	300,616

Sources: Preprint from the 1969 Bureau of Mines *Minerals Yearbook*, United States Department of the Interior, for 1967 figures. United States Department of the Interior, Bureau of Mines, Mineral Industry Surveys 'Mercury in the First Quarter 1972' for 1970 and 1971 statistics.
[1]Official figures as reported by Statistical Office, Secretary of Industry and Commerce, Mexico; over-all production of mercury believed to be much higher.
[p]Preliminary; [e]Estimated; . . Not available.

Clair and Lake Erie were found, early in 1970, to have relatively high mercury levels and were declared unsafe for consumption. It was eventually proven that the main source of the contamination was the mercury contained in effluents discharged into those waters from chlorine-caustic soda manufacturing plants located in the area concerned. Very little time was required to virtually eliminate any further contamination of these waters, but the problem of how to remove the mercury from the bottom of these and other lakes and rivers where it has been dumped for years remains unsolved. Although demand for mercury in other foreign countries in 1971 appears to have been better than in the United States, the worldwide environmental problem and antipollution legislation have already begun to adversely affect the use of mercury as a cathode in the electrolytic preparation of chlorine and caustic soda, one of its two major uses. The danger of mercury poisoning has also cut into other markets for mercury, such as in the agriculture and pulp and paper industries.

A weakness in the mercury market attributed to oversupply coupled with a reduced demand, which developed in 1970, continued in 1971. As a result, prices again declined substantially. Because of the unfavourable market conditions, no monthly offerings nor commercial sales were made by General Services Administration (GSA) from the surplus stocks of mercury held in United States Government stockpiles. The last such sale was made in June 1970 and between then and the end of December 1971, GSA sales were confined to other U.S. Government agencies. In 1971 GSA sold 5,767 flasks to government agencies. Of this amount, 5,700 flasks went to the Agency for International Development, which subsequently delivered them to India. Market conditions were somewhat aggravated by substantial increases in production in some countries, including Spain, Algeria and Czechoslovakia. The New York mercury price declined almost continuously in 1971 from about $360 a flask at the beginning of the year to approximately $220 at year-end, the lowest since December 1963.

At the end of 1971, United States Government stockpiles contained a total of 200,105 flasks of mercury; the stockpile objective remaining unchanged at 126,500 flasks. The surplus of 73,605 flasks, however, requires Congressional approval before it can be released. These stocks are exclusive of excess mercury held by the United States Atomic Energy Commission (AEC). In June 1969, these surplus AEC stocks, which do not require Congressional authorization prior to being sold, were declared to be 15,000 flasks. Between then and the end of 1971, a total of 7,276 flasks of this surplus AEC mercury were sold, leaving an unsold balance of 7,724 flasks.

The 10 per cent ad valorem import surcharge announced by President Nixon on August 15, 1971 had the effect of raising the duty, effective August 16, 1971, on imports of Canadian mercury metal from 15¢ per pound to the statutory limit of 25¢ per pound. On December 20, 1971 the President signed a proclamation rescinding immediately this 10 per cent surcharge on foreign imports.

Outlook

Fears of pollution continued to weaken the demand for mercury and caused a further decline in prices in 1971. The New York mercury price reached an all-time high of $775 a flask in June 1965 and from then until the end of 1968 it fluctuated considerably. From the beginning of 1969 through the end of 1971 the trend was steadily downward. However, as a result of some restrictions in output and market withdrawals, prices should show some improvement in the latter part of 1972. Over the next few years, however, mercury prices are expected to fluctuate, mainly because of erratic demands.

Because of the environmental hazards involving several of the metal's uses, as well as the slow improvement in the United States and other economies, the outlook for mercury for 1972 and some years thereafter is thought to be somewhat less favourable than it has been in recent years. In one of mercury's major markets, the electrolytic production of chlorine and caustic soda, the trend may continue to be toward a greater use of diaphragm cells (in which mercury is not required), instead of mercury cells, in the installation of such new manufacturing plants and expansion of existing facilities. Because of the United States Government's declared surplus of some 73,600 flasks, together with some 7,700 flasks of surplus AEC stocks available for disposal, an oversupply appears to be in prospect for 1972 and at least an adequate supply for some years thereafter. Any significant reduction in output by any of the major producers would have a beneficial effect. Also, much will depend on whether or not Spain and Italy, two of the leading producing countries, continue to withhold part of their supplies from the market.

Table 4. United States mercury consumption, by uses, primary and secondary in origin

	1967	1970	1971p
		(flasks)	
Agriculture	3,732	1,811	1,477
Amalgamation	219	219	*
Catalysts	2,489	2,238	1,141
Dental preparations	2,386	2,286	2,387
Electrical apparatus	16,223	15,952	16,938
Electrolytic preparation of chlorine and caustic soda	14,306	15,011	12,262
General laboratory use	1,940	1,806	1,809
Industrial and control instruments	7,459	4,832	4,871
Paint:			
antifouling	152	198	414
mildew-proofing	7,026	10,149	8,191
Paper and pulp manufacture	446	226	*
Pharmaceuticals	283	690	682
Other[1]	12,856	5,858	2,300
Total known uses	69,517	61,276	52,472
Total uses unknown	–	227	3
Grand total	69,517	61,503	52,475

Sources: Preprint from the 1970 Bureau of Mines *Minerals Yearbook*, United States Department of the Interior, for 1967 and 1970 figures. United States Department of the Interior, Bureau of Mines, Mineral Industry Surveys 'Mercury in the First Quarter 1972' for 1971 statistics.
[1]Includes mercury used for installation and expansion of chlorine and caustic soda plants, and quantities in 1971 for categories listed as not available for publication.
pPreliminary; – Nil; *Data not available for publication.

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, although the latter use has been declining. Together these two uses accounted for about 56 per cent of mercury consumed in the United States in 1971. Electrical uses include mercury lamps, batteries, rectifier bulbs, oscillators, and various kinds of switches including 'silent' switches for use in the home. Because mercury lamps are adaptable to higher-voltage supply lines than those 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 conditions of 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.

Table 5. Average monthly prices of mercury in 1971 at New York, London and cif main European port

	New York[1]	London[2]	CIF main European port[3]	
			Low	High
	($ U.S./flask)	($ U.S. equiv./flask)		
January	349.500	508.80	348.53	358.39
February	348.263	513.04	351.51	361.19
March	328.261	513.04	327.76	337.73
April	309.952	513.04	310.06	317.32
May	281.500	513.04	279.21	287.38
June	266.227	513.04	244.42	253.19
July	297.952	513.04	271.31	280.99
August	283.864	517.28	250.41	259.86
September	283.095	523.64	253.18	264.60
October	271.350	527.88	244.99	253.01
November	258.750	527.88	235.17	241.81
December	230.238	540.60	215.16	223.76

Sources: *Metals Week* for New York prices; *Metal Bulletin (London)* for London and cif main European port prices.
[1]Prime virgin metal. [2]Prices are producer ex-warehouse basis, and usually nominal. [3]Prices are cif main European port, min. 99.99%.

Other important applications are in mildew-proofing paints, industrial and control instruments, pharmaceuticals, insecticides, fungicides, bactericides, and dental preparations. Several mercury compounds, especially the 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. Mercury is superior to wax, wood or plastic pattern materials because of its smooth surface and uniform expansion upon heating. New technologies could open up new areas of use in the nuclear field, metal-chloride vapours, plastics, chemicals, amalgams and ion exchange.

Prices

The price of mercury per flask, fob New York, as quoted in *Metals Week,* fluctuated in 1971 between a high of $360 in January and a low of $218 in December. Average for the year was $292.41 a flask compared with an average of $407.77 for 1970. The London ex-warehouse price, as quoted in *Metal Bulletin (London)*, remained at £212 per flask throughout the year but this quotation was usually reported as 'nominal'.

Tariffs

Canada

Item No.		British Preferential	Most Favoured Nation	General
92805-2	Mercury metal	free	free	free
92828-4	Mercuric oxide for manufacture of dry-cell batteries (expired January 31, 1972)	free	free	25%

United States

Item No.		On and After January 1 1970	1971	1972
		(cents per pound)		
601.30	Mercury ore	free	free	free
632.34*	Mercury metal, unwrought and waste and scrap	17	15	12.5

Sources: The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa. Tariff Schedules of the United States, Annotated (1972) TC Publication 452.

*Duty on waste and scrap suspended to June 30, 1973.

Molybdenum

G.P. WIGLE

Molybdenum shipped by producers in Canada in 1971 was 28.3 million pounds valued at $47 million compared with 33.8 million pounds valued at $57.1 million in 1970. Molybdenum exports were 22.9 million pounds valued at $44.9 million compared with 30.3 million pounds valued at $60.9 million in 1970. The sharp decline of shipments and exports was due to reduced demand in overseas markets. Canadian mine production of molybdenum was approximately 33 million pounds; the major part of the oversupply was in producers' accumulated stocks of unsold concentrates.

Noncommunist world production of molybdenum in 1971 was an estimated 151 million pounds; it was 162 million pounds in 1970. The principal reductions in output were made by the larger Canadian and United States producers in the expectation that deliveries from reduced current production and the large inventories of unsold concentrates would still exceed demand into 1974. Mining projects recently completed and approaching completion for the production of copper and byproduct molybdenum in Canada and the United States will raise noncommunist world capacity to nearly 182 million pounds by the end of 1972. Consumption, increasing at an annual rate of 7 per cent, will overtake that capacity about two years later.

The producer's prices of molybdenum established by American Metal Climax, Inc. in May 1969, remained unchanged through 1970 and 1971 at U.S. $1.72 a pound of contained molybdenum in molybdenite (MoS_2) concentrates, and U.S. $1.92 a pound of contained molybdenum in molybdenum trioxide (MoO_3). Published prices in 1971 indicated byproduct molybdenite concentrates, depending on grade, at U.S. $1.52-$1.71 a pound of molybdenum and dealer molybdic oxide for export at U.S. $1.82-$1.90 a pound of contained molybdenum. *Metal Bulletin* during December 1971 gave prices of $1.70-$1.75 a pound of molybdenum, in concentrates of some other origin, c.i.f. eastern European ports.

The United States Office of Emergency Preparedness abolished the molybdenum stockpile objective in February 1971. The stockpile at the end of December 1971, remaining the same as at the beginning of the year, contained 41.3 million pounds of molybdenum consisting of 22.8 million pounds in MoS_2 concentrates, 11 million pounds in molybdic oxide (MoO_3) and 7.5 million pounds in ferromolybdenum. Disposal of the stockpile material was to be made within legislative guidelines and in a manner to avoid disruption of producer's markets.

Production

Brenda Mines Ltd., some 24 miles west of Kelowna, British Columbia, reached production early in 1970 and completed a full production year in 1971. The milling rate was 24,662 tons of ore a day. The grade of ore milled was 0.22 per cent copper and 0.062 per cent molybdenum. Recoveries were 89.77 per cent for copper and 86.13 per cent for molybdenum. Production included 9.6 million pounds of molybdenum; 5.1 million were sold and 7.6 million pounds were in inventory at the end of 1971. Sale of current production was anticipated for 1972. Ore reserves at the end of 1971 were 154 million tons grading 0.182 per cent copper and 0.048 per cent molybdenum.

British Columbia Molybdenum Limited, a subsidiary of Kennecott Copper Corporation, produced 5.1 million pounds of molybdenum in 1971. Operations were reduced to a 5-day week due to lack of sales and with a revenue of $7 million the net loss on operations was $3.2 million. The company reported in April 1972 that the operation would close the following month.

Table 1. Canada, molybdenum production, trade and consumption, 1970-71

	1970		1971p	
	(pounds)	($)	(pounds)	($)
Production (shipments)[1]				
British Columbia	31,276,497	52,561,796	27,259,000	42,250,000
Quebec	2,495,219	4,578,778	1,065,000	1,890,000
Total	33,771,716	57,140,574	28,324,000	47,140,000
Exports				
Molybdenum in ores and concentrates				
Britain	8,307,100	16,011,000	5,784,300	10,995,000
Netherlands	4,850,900	9,758,000	5,359,500	10,907,000
Japan	5,029,900	11,173,000	3,939,200	8,623,000
France	4,761,200	9,123,000	2,999,300	5,561,000
Belgium & Luxembourg	2,482,100	4,657,000	1,368,400	2,479,000
Sweden	1,028,500	2,167,000	1,153,000	2,173,000
Italy	762,100	1,692,000	915,900	1,559,000
West Germany	1,786,000	3,603,000	771,300	1,385,000
Poland	175,000	345,000	253,500	457,000
Brazil	299,700	616,000	221,500	451,000
Other countries	851,500	1,825,000	178,900	315,000
Total	30,334,000	60,970,000	22,944,800	44,905,000
Imports				
Molybdic oxide (gross weight)	73,900	82,000	64,600	97,000
Molybdenum in ores and concentrates from United States[2] (Mo content)	517,432	845,866	1,352,540	..
Ferromolybdenum from United States[2]	65,299	144,310	15,156*	25,655*
Consumption (Mo content)				
Ferrous and nonferrous alloys	2,163,522	..	..	..
Electrical and electronics	13,345	..	..	..
Other uses[3]	109,194	..	..	..
Total	2,286,061			

Source: Statistics Canada.
[1]Producers' shipments (Mo content) of molybdenum conc., molybdic oxide and ferromolybdenum. [2]United States exports of molybdenum in ores and concentrates and ferromolybdenum (gross weight) 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. [3]Chiefly pigment uses. *First 10 months only. pPreliminary; ..Not available.

Endako Mines Ltd. was amalgamated with Placer Development Limited under the name of the latter company in 1971. Production was reduced at Endako to 75 per cent of the previous year's output in August 1971 and was to be reduced further to 50 per cent in March 1972. The company's accumulation of unsold molybdenum in concentrates was 10 million pounds. During 1971 Endako treated 9,051,000 tons of ore at an average grade of 0.162 MoS_2 to produce a total of 14,387,736 pounds of contained molybdenum consisting of 5,163,787 pounds in molybdenite concentrate and 9,223,949 pounds in molybdic oxide.

Noranda Mines Limited suspended operations on December 3, 1971, at its Boss Mountain Division of Brynnor Mines Limited. The indefinite suspension was due to reduced demand for molybdenum in overseas markets and the large stocks of molybdenum in concentrates already accumulated by producers. Boss Mountain production in 1971 was 2,010,000 pounds of molybdenum compared with 2,456,000 pounds in 1970. Ore reserves above the adit level at the end of 1971 were 2.7 million tons grading 0.25 per cent molybdenum. It was planned to continue limited underground work till June 1972.

Table 2. Canada, molybdenum production, trade and consumption, 1961-71
(pounds)

	Production[1]	Exports[2]	Imports		Consumption[5]
			Molybdic oxide[3]	Ferro-molybdenum[4]	
1961	771,358	..	266,399	211,779	1,135,610
1962	817,305	..	328,424	121,358	1,261,380
1963	833,867	..	258,765	125,869	1,306,193
1964	1,224,712	..	490,500	271,605	1,261,454
1965	9,557,191	..	759,500	398,460	1,702,589
1966	20,596,044	..	665,500	522,800	1,261,387
1967	21,376,766	23,792,700	452,600	316,692	1,430,895
1968	22,464,273	22,704,500	1,359,300	284,600	1,543,432
1969	29,651,261	25,672,600	76,600	482,609	1,808,772[r]
1970	33,771,716	30,334,000	73,900	65,299	2,286,061
1971[p]	28,324,000	22,944,800	64,600	15,156 *	1,814,586

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 Produce, gross weight. [5] Mo content of molybdenum products reported by consumers. *First 10 months 1971. [p] Preliminary; [r] Revised; .. Not available.

Developments

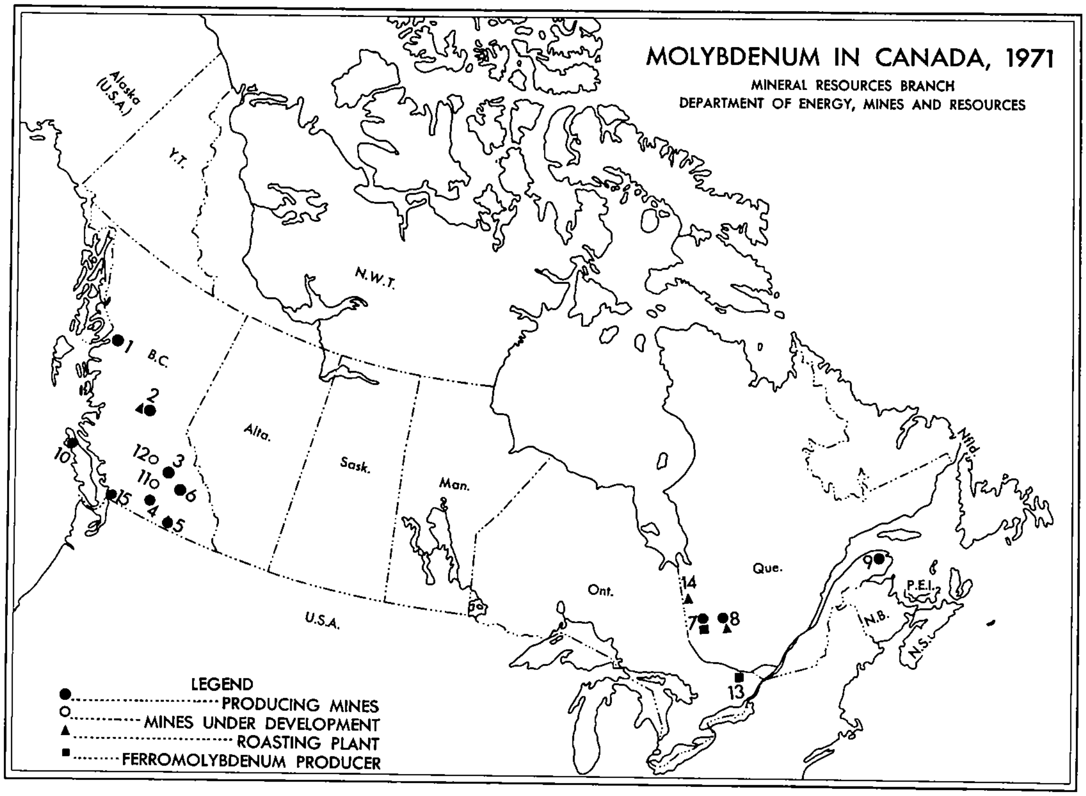
Canada. Utah International Inc. started operation at its Island Copper mine near Port Hardy on Vancouver Island in October 1971. This copper-molybdenum mining and concentrating operation was expected to be in full production about January 31, 1972. Design capacity was 33,000 tons a day and annual output was estimated at 53,000 tons of copper and 1.9 million pounds of molybdenum. Ore reserves were estimated at 280 million tons averaging 0.52 per cent copper and 0.029 per cent molybdenum.

Lornex Mining Corporation Ltd., managed by Rio Algom Mines Limited, prepared to start production in the first half of 1972 at its large copper-molybdenum property some 33 miles south of Ashcroft in the Highland Valley of British Columbia. It was estimated that $138 million would be required to complete the project with design capacity of 38,000 tons of ore a day. The orebody was estimated to contain 293 million tons averaging 0.427 per cent copper and 0.014 per cent molybdenum. Annual production was expected to be about 54,000 tons of copper and 3.0 million pounds of molybdenum.

Gibraltar Mines Ltd. started low-capacity trial-production operation in March 1972 at its copper-molybdenum property at McLeese Lake in the Cariboo district of British Columbia. The new mine and plant have a capacity of 30,000 tons of ore a day. Placer Development Limited, is the principal owner with a 71 per cent interest. Ore reserves were estimated at 358 million tons averaging 0.373 per cent copper and 0.016 per cent molybdenite (MoS_2). Capital expense of bringing the property to production was estimated at $74 million.

Highmont Mining Corp. Ltd. proceeded with feasibility studies and arrangements for the sale of concentrates from its copper-molybdenum property adjoining east of Lornex in the Highland Valley. If a production decision were reached it was planned to complete a plant with a capacity of 25,000 tons of ore a day at an estimated capital expenditure of $63 million. Reserves were estimated at 145 million tons averaging 0.27 per cent copper and 0.045 per cent molybdenite (MoS_2).

Among other molybdenum and copper-molybdenum properties in British Columbia explored and studied for their production possibilities were those of Adanac Mining and Exploration Ltd. about 14 miles northeast of Atlin near the Yukon border, Bell Molybdenum Mines Limited near Alice Arm, Della Mines Ltd. in the Cassiar district, Sileurian Chieftain Mining Company Limited in the Alice Arm area, and Valley Copper Mines Limited in the Highland Valley.



Producing Mines
(numbers refer to numbers on map)

1. British Columbia Molybdenum Limited
2. Placer Development Limited (Endako Mine)
3. Brynnor Mines Limited (Boss Mountain)
4. Brenda Mines Ltd.
5. Red Mountain Mines Limited
6. King Resources Company Mount Copeland Mine
7. Preissac Molybdenite Mines Limited
8. Molybdenite Corporation of Canada Limited
9. Gaspé Copper Mines, Limited
10. Utah International Inc. (Island Copper Mine)

Mines under development

11. Lornex Mining Corporation Ltd.
12. Gibraltar Mines Ltd.

Processing Plants

2. Placer Development Limited (Endako Mine)
7. Preissac Molybdenite Mines Limited
8. Molybdenite Corporation of Canada, Limited
13. Masterloy Products Limited (ferroalloy plant)
14. Beattie-Duquesne Mines Limited (roaster)
15. Fundy Chemical Corporation Limited (ferroalloy plant)

United States. Molybdenum producers in the United States account for 70 per cent of noncommunist world annual production. The United States is the foremost exporter of molybdenum amounting to about half its domestic production and more than half of present overseas demand. Exports of molybdenum in ores and concentrates were 57.6 million pounds valued at $99 million in 1969, and 55.7 million pounds valued at $95.2 million in 1970.

United States exports of molybdenum products in 1969, in terms of gross weight and value, were: ferromolybdenum, 727 tons valued at $2.4 million; semifabricated forms, 115 tons, $682,000; wire, 61,000 pounds, $1,083,000; powder, 44,000 pounds, $168,000; and crude metal and alloys, 21,000 pounds valued at $70,000. In 1970 exports of molybdenum products, again in gross weight and value were: ferromolybdenum 1,007 tons valued at $3.1 million; semifabricated forms, 116 tons, $643,000; wire, 107,000 pounds, $1,252,000; powder, 329,000 pounds, $528,000; and crude metal and alloys, 671,000 pounds valued at $802,000.

Table 3. Molybdenum production in ores and concentrates, 1969-71*

(Mo content, thousands of pounds)

	1969	Per Cent of Total	1970	Per Cent of Total	1971[e]	Per Cent of Total
United States	99,807	69.97	111,352	68.77	108,000	71.52
Canada	29,651	20.79	33,772[r]	20.86	28,324[p]	18.54
Chile	10,675	7.48	13,448	8.31	12,000	7.95
Peru	494	0.35	1,167	0.72		
South Korea	287	0.20	254	0.16		
Japan	593	0.42	974	0.60	(3,000)	1.99
Norway	635	0.44	553	0.34		
Mexico	445	0.31	311	0.19		
Philippines	51	0.04	71	0.05		
Total	142,638	100.00	161,902	100.00	151,324	100.00

Sources: U.S. Bureau of Mines, *Minerals Yearbook*; Statistics Canada; company reports.
*Excludes U.S.S.R. and China. [e]Estimated; [r]Revised; [p]Preliminary; (3,000) Average of prior two years.

New molybdenum production facilities planned for completion during the next 5 years will maintain United States dominance among world molybdenum producers by a wide margin until at least 1980 despite the completion of presently planned production increases in other countries.

American Metal Climax, Inc. (AMAX), the largest single producer of molybdenum, produced a record 67 million pounds in 1970; 59 million pounds came from the Climax mine and 8 million from the Urad mine, both in Colorado. The Climax mine is reported to have 430 million tons of ore reserves averaging 0.35 per cent molybdenite (MoS_2). The largest of the new molybdenum mines being developed for production is the AMAX Henderson mine, near the Urad, that AMAX expects to bring into production in 1975 with an annual capacity of 50 million pounds of molybdenum. The Henderson orebody contains an estimated 303 million tons of ore averaging 0.49 per cent molybdenite (MoS_2). The estimated capital expenditure to complete the Henderson project was $250 million.

Japan. Molybdenum consumption in Japan has grown from about 5 million pounds in 1960 to over 16 million pounds in 1969. Canada's exports of molybdenum to Japan were 5.03 million pounds in 1970 and 3.94 million pounds in 1971 with an aggregate value of $19.8 million.

Japan's rapidly increasing steel production and the growing use of molybdenum in steelmaking make it an important customer for Canada's molybdenum output. Japan could require over 25 million pounds of molybdenum in 1975 and some 40 million pounds in 1980. Japan produces about 500,000 pounds of molybdenum a year from its own mineral resources.

In September 1970 American Metal Climax, Inc. and a group of 10 Japanese companies commenced operating a 12-million-pound-a-year molybdenite conversion plant in Japan. AMAX has a 34 per cent share of the equity in the $5.5-million roaster; the remaining 66 per cent is apportioned among the Japanese participants. The design capacity of this modern roaster is similar to the capacity of the molybdenite roasting plant at Rotterdam, Netherlands, that is operated by a subsidiary of AMAX.

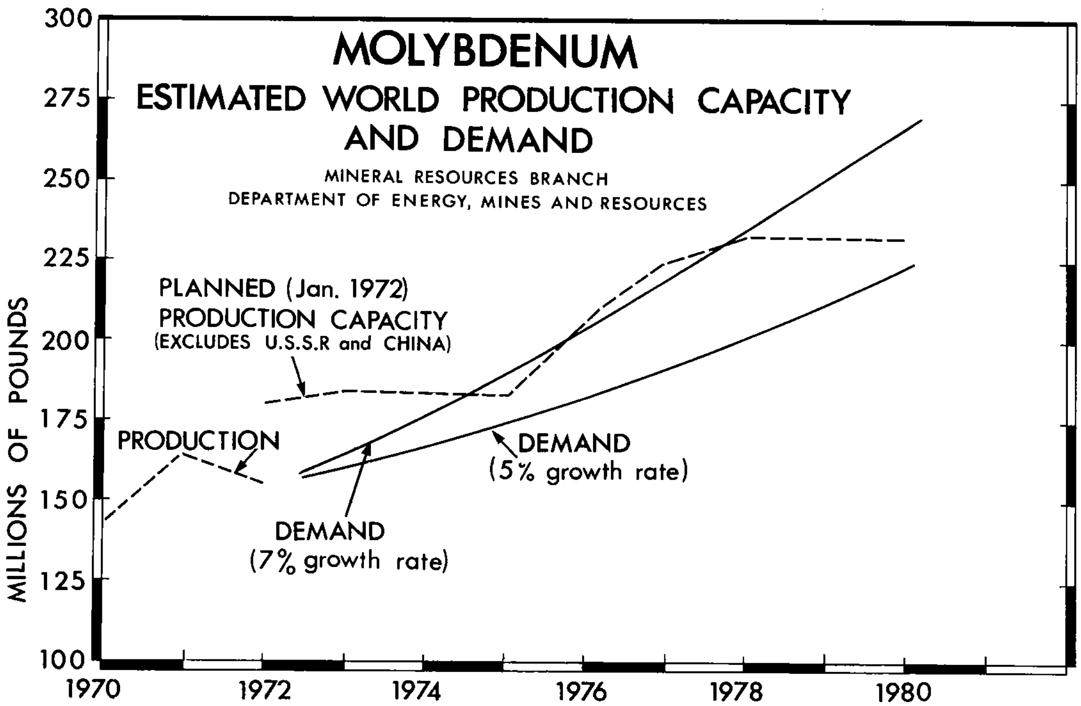
Outlook

Molybdenum production in the noncommunist countries was an estimated 151 million pounds in 1971 compared with 162 million pounds in 1970. Production capacity increased in 1971 nearly 10 per cent to about 175 million pounds a year with the advent of new copper-molybdenum producing mines. Molybdenum producers will have surplus capacity until at least 1975 and accumulated stocks may not be disposed of at that time unless production and stockpile sales remain below current demand.

Products and uses

The steel and iron industries are the principal consumers of molybdenum, accounting for over 80 per cent of total consumption. The balance is used in high-temperature alloys as molybdenum metal, in lubricants, chemicals, pigments and in catalysts.

Approximately 70 per cent of United States molybdenum consumption was in the form of molybdic oxide (MoO_3), some 22 per cent was used as ferromolybdenum, and about 4 per cent as molybdenum powder. Molybdenum is used in lesser amounts in the molybdates of ammonium, sodium and calcium,



as purified molybdenite in lubricants, and as molybdenite for direct addition to steel when sulphur is also to be added.

Molybdenite concentrate is roasted to form technical-grade molybdic oxide (MoO_3) which is the starting material for manufacturing most other molybdenum products. Technical-grade molybdic oxide, or roasted molybdenite concentrate, is also made into briquettes with pitch and both forms of MoO_3 are used to add molybdenum to steel and iron. Molybdic oxide is also used to make ferromolybdenum containing 55 to 75 per cent Mo, an additive which is adaptable to any steel-making process. Ferromolybdenum is made in the electric arc furnace or by the thermite process.

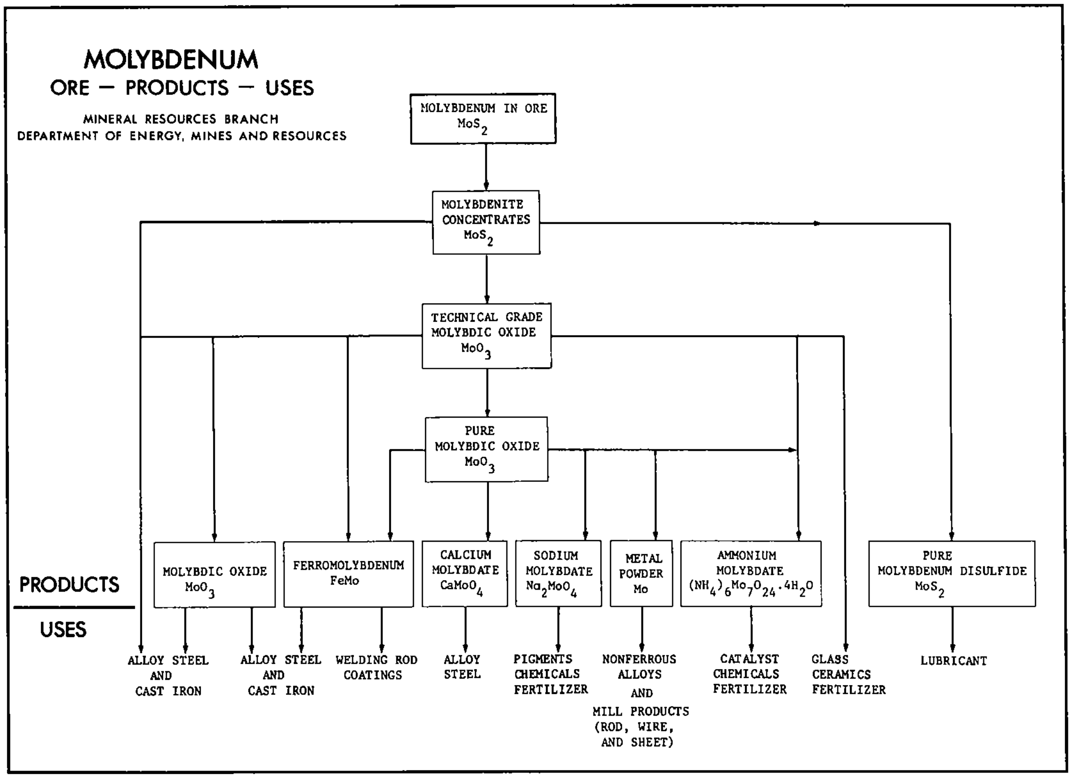
Typical analyses of molybdenite concentrate and the roasted product from it, molybdic oxide from the Endako Mine, are:

	MoS_2 concentrate (%)	MoO_3 concentrate (%)
Molybdenum	53	59-60
Copper	0.015	0.017
Lead	0.006	0.006
Bismuth	0.015	0.017
Iron	0.14	0.015
Silica	6.5	7.0
Moisture and reagents	4-6	sulphur 0.05-0.10

Table 4. United States consumption of molybdenum by end use, 1969-70
(thousands of pounds of contained molybdenum)

	1969	1970
Carbon steel	3,536	2,882
Stainless and heat resisting	6,259	5,163
Alloy steel	21,105	18,014
Tool steel	3,486	2,246
Cast irons	4,274	3,741
Superalloys	2,516	2,418
Cutting- and wear-resistant materials	3	..
Welding and hardfacing rod and materials	412	331
Other alloys and nonferrous alloys	196	98
Mill products made from metal powder	1,899	1,717
Chemical and ceramic uses		
Pigments	1,102	966
Catalysts	1,514	863
Other	820	479
Miscellaneous and unspecified	4,501	4,089
Total	51,623	43,007

Source: Mineral Industry Surveys, U.S. Bureau of Mines
.. Not available.



Small additions of molybdenum promote uniform hardness, hardenability and toughness and are used in making many kinds of steels. Adding molybdenum to molten steel is a straightforward operation, losses are small, and it is commonly added in the oxide form or as ferromolybdenum. It raises the strength of low- and high-alloy steels for use at high temperatures. It improves the corrosion resistance of chromium-nickel stainless steels giving a superior product for handling of corrosive chemicals.

The petroleum and chemical industries use molybdenum as a catalyst and in structural components of process equipment and containers. It is also used in the production of pigments for inks, lacquers and paints noted for their permanence and brilliance. Molybdenum metal and molybdenum-base alloys are used in high-temperature applications, thermocouples, electronics, missile parts and in structural parts of nuclear reactors. Small amounts of sodium molybdate are used to replace molybdenum deficiencies in soils.

Ore occurrences and grade

Molybdenum (Mo) does not occur in the free uncombined metallic form in natural mineral occurrences. Production is from deposits carrying the sulphide mineral molybdenite, MoS_2; other molybdenum-bearing minerals are relatively rare and of minor importance. More than 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 deposits, some from tungsten-molybdenum mines, and minor amounts 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 about 0.50 per cent MoS_2, or 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 to two per cent MoS_2.

Prices

Prices in U.S. dollars per pound of contained molybdenum f.o.b. shipping point

	Dates of Price Changes		
	Jan. 11, 1967	May 5, 1969	Dec. 31, 1971
	(U.S. $)	(U.S. $)	(U.S. $)
Molybdenum concentrates, 95% MoS_2, containers extra	1.62	1.72	1.72
molybdic oxide (MoO_3)			
in bags	1.81	1.91	1.91
in cans	1.82	1.92	1.92
Ferromolybdenum, 0.12-0.25% C, 5,000 lb lots			
lump	2.11	2.21	2.21
powder	2.17	2.27	2.27
Molybdenum powder, f.o.b. shipping point hydrogen reduced, 99.95% per lb		3.73	4.00

Tariffs

Canada

Item No.		British Preferential	Most Favoured Nation	General
		(%)	(%)	(%)
32900.1	Molybdenum ores and concentrates	free	free	free
35120.1	Molybdenum and alloys in powder, pellets, scrap, ingot, sheets, strip, plate, bars, rods, tubing and wire for use in Canadian manufactures. Expires October 31, 1971.	free	free	25
92828.1	Molybdenum oxides and hydroxides	10	15	25
37506.1	Ferromolybdenum	free	5	5

United States

Item No.		On and After Jan. 1, 1971	On and After Jan. 1, 1972
		(¢ per lb on Mo content)	
601.33	Molybdenum ores and concentrates	14	12
418.26	Calcium molybdate	12 + 3.5%	10 + 3%
419.60	Molybdenum compounds	12 + 3.5%	10 + 3%
628.72	Molybdenum metal, unwrought	12 + 3.5%	10 + 3%
607.40	Ferromolybdenum	12 + 3.5%	10 + 3%
		(%)	(%)
628.74	Molybdenum metal, wrought	15	12.5
628.70	Molybdenum metal, waste and scrap (suspended)	12.5	10.5

Sources: The Customs Tariff and Amendments, Department of National Revenue, Customs and Exise Division, Ottawa. Tariff Schedules of the United States Annotated (1971).

Natural Gas

J. W. FRASER

Further indications of the anticipated large oil and gas potential in Canada's frontier areas were given in 1971 by the first significant oil and gas discovery in the east coast offshore areas and additional discoveries in the Canadian north. Of particular importance as new gas reserves were the discoveries in the Mackenzie Delta, in the Arctic islands and the indicated gas-bearing zones of an oil and gas discovery on Sable Island off the Nova Scotia coast. Although full information is not available on these occurrences, there are indications that they could be major supply sources in the future. However, until reserves in these areas are proven and are connected to markets by pipeline, Canadian domestic and export requirements will continue to be met from the established producing districts in western Canada. During 1971, total net withdrawals from all Canadian sources amounted to 2,500,751 MMcf, or 6,851 MMcf/d*. While this represented an increase of 9.8 per cent over the 1970 level, it was lower than the very high annual increases of 1969 and 1970. Gas consumption by commercial and industrial customers showed particularly strong growth as sales by utilities in Canada rose to 2,743 MMcf/d, valued at $642 million for the year. Export shipments were also considerably higher, rising by 16.8 per cent to 2,495 MMcf/d.

Although no single discovery made in western Canada during 1971 seems comparable to the major finds reported from the frontier areas, widespread exploration and development activity in Alberta, northeastern British Columbia and western Saskatchewan contributed to a steady growth in gas reserves. Thus, in spite of the substantial increase in production, total proved remaining marketable reserves in Canada rose from 53,375,628 MMcf at the end of 1970 to 55,461,850 MMcf at the end of 1971. The increase amounted to 3.9 per cent during 1971, most of which was attributable to additions in Alberta.

The adequacy of Canadian gas reserves to meet future requirements was an important issue in 1971 as a result of industry applications to increase gas exports to the United States. Applications for licences to export a total of 2.66 trillion cubic feet over the next 20 years were made to the National Energy Board (NEB) by two companies which had been unable to obtain the full export increases they had requested in 1970, and a third company that had its application rejected in 1970. Before considering these specific applications the NEB held hearings to determine if surplus gas was available for export, taking into consideration such factors as current reserves, recent discovery trends, existing export commitments and future Canadian requirements. After assessing all pertinent factors, the NEB decided that there was no surplus gas in Canada at that time and the applications were dismissed. In arriving at its decision the NEB did not include the indicated reserves in the frontier regions since they were not proven. The expectation is that substantial reserves will be proven. Therefore, a great deal of investigation related to northern pipeline construction is under way by both industry and government. Current indications are that the first application to build a gas pipeline from northern Canada might be made by early 1973, and that northern reserves could be made available by the latter half of the 1970's.

*MMcf/d = 1,000,000 cubic feet per day.

Table 1. Canadian natural gas fields producing 10 million Mcf or more, 1970-71[1]

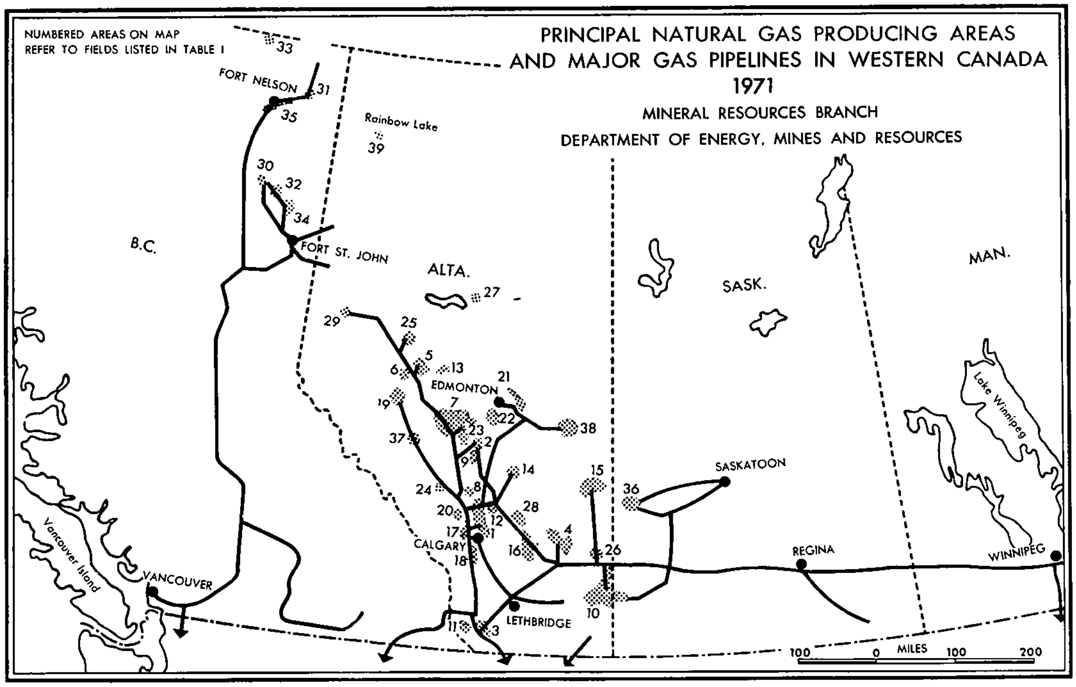
	1970	1971		1970	1971
(numbers in brackets refer to map location)	(Mcf)	(Mcf)	(numbers in brackets refer to map location)	(Mcf)	(Mcf)
Alberta			Westlock (21)	16,233,419	18,474,273
Crossfield (1)	154,367,756	157,710,434	Jumping Pound (17)	19,255,284	18,376,792
Kaybob South (25)	95,113,312	107,036,467	Swan Hills (13)	17,448,125	17,648,812
Edson (19)	105,121,126	104,855,819	Pine Creek (6)	22,003,808	16,627,350
Waterton (11)	94,857,498	92,829,621	Viking-Kinsella (38)	14,435,438	16,093,557
Westerose South (2)	93,296,817	92,446,598	Lone Pine Creek (1)	14,476,058	15,250,404
Strachan (24)	421,838	70,973,782	Wimborne (12)	14,914,607	15,161,814
Windfall (5)	76,051,777	61,749,368	Bindloss (26)	15,814,042	14,753,799
Crossfield East (1)	57,681,683	58,765,136	Alderson (10)	13,188,026	14,071,950
Medicine Hat (10)	61,807,677	58,408,954	Olds (12)	13,865,799	13,442,187
Harmattan-East (8)	50,911,678	54,190,550	Fort Saskatchewan (21)	14,151,466	13,398,910
Homeglen-Rimbey (9)	51,490,694	51,589,250	Wayne-Rosedale (3)	13,021,798	12,411,535
Harmattan-Elkton (8)	50,121,890	49,775,970	Turner Valley (18)	12,885,062	12,350,423
Pembina (7)	45,378,692	47,878,145	Countess (16)	12,175,735	12,103,510
Cessford (4)	48,215,969	46,916,812	Pincher Creek (3)	13,611,416	11,336,328
Marten Hills (27)	37,688,147	46,585,466	Gold Creek (29)	7,459,936	10,974,035
Carstairs (12)	48,805,481	45,515,514	Bonnie Glen (22)	9,202,187	10,858,628
Brazeau River (37)	38,773,018	45,074,337	Atlee Buffalo (26)	5,192,861	10,634,212
Gilby (9)	45,218,834	44,653,479	Swan Hills South (13)	8,162,170	10,472,101
Provost (15)	41,681,555	41,795,492	Okotoks (18)	9,162,357	10,188,568
Nevis (14)	41,302,333	41,127,918			
Jumping Pound West (17)	28,159,621	41,107,454	**British Columbia**		
Wildcat Hills (20)	34,428,750	37,135,014	Clarke Lake (35)	104,278,387	94,112,768
Ferrier (8)	32,348,996	34,159,999	Yo Yo (31)	48,064,498	37,462,939
Kaybob (25)	26,195,788	31,931,890	Laprise Creek (30)	25,908,115	24,175,857
Carson Creek (13)	25,612,079	27,401,853	Rigel (34)	16,791,212	22,805,490
Ghost Pine (28)	28,529,412	26,742,698	Nig Creek (32)	16,584,423	17,756,522
Minnehik-Buck Lake (23)	22,513,798	25,381,260	Jedney (30)	17,311,108	16,764,879
Sylvan Lake (2)	23,433,959	22,178,062	Sierra (31)	9,886,456	15,969,175
Quirk Creek (18)	30,800	22,020,011	Stoddart (34)	12,635,773	15,602,264
Lookout Butte (3)	24,509,944	21,770,492	Beaver River (33)	–	12,520,830
Judy Creek (13)	20,406,621	21,316,793	Buick Creek (32)	10,768,622	11,246,207
Rainbow (39)	18,404,128	19,540,601			
Hussar (16)	20,880,820	18,715,968	**Saskatchewan**		
Bigstone (25)	17,806,972	18,476,865	Coleville-Smiley (36)	12,339,918	11,662,481

Source: Provincial government reports. [1]14.65 psia. – Nil.

Outlook

Strong demand pressure for Canadian gas from both domestic and export markets will continue through 1972 and for the foreseeable future. However, it appears that a greater share of Canadian production will be utilized to meet the anticipated growth in domestic markets until sufficiently large increases in reserves can be made to once again establish a gas surplus for export. Large volumes of gas in Alberta had been contracted for export to the United States in anticipation of the approval of additional export licences in the last two years. However, these export approvals were not obtained. On the other hand, very strong growth is forecast in Canadian markets, particularly in Ontario. It seems likely that some of the gas originally contracted for export will now move to Canadian markets, provided that suitable agreements can be reached between Canadian buyers and the companies that control these reserves. At year-end, Trans-Canada Pipe Lines Limited was negotiating for additional supplies with producers in Alberta.

Price increases at the producer level seem likely as a result of several factors. In addition to the continuing rise in normal operating costs, new cost



pressures on producing companies are arising from environmental protection requirements, such as the cost of new equipment to meet increased sulphur removal requirements at gas-processing plants. Some indication of the price increases which may be expected is given by the terms of an arbitration award resulting from negotiations between Westcoast Transmission Company Limited and a group of 25 owner companies for gas from the Petrogas Processing Ltd. processing plant in Alberta. Under the new price structure, the producers will receive 21.65¢/Mcf in 1972 instead of 17.25¢/Mcf they would have received under the old agreement. There are also provisions in the arbitration award for annual one-cent increases up to 1975, after which the price will be renegotiated for the years 1976 and later. Since many Alberta gas contracts provide for renegotiation late in 1972 and 1973, this agreement is expected to have an impact on a new price structure in many cases. Trans-Canada, which buys gas from western producers for resale to utilities, has also won increases from utilities and regulatory authorities to meet increasing gas-purchase costs and to provide for the financing of new facilities. The need for producer price increases has been accepted in many sectors as necessary to provide funds for the continuing and costlier development of new reserves as well as the development of longer transportation and distribution systems to bring gas to consumers. The final effect on consumer prices is hard to determine in detail at present but it will eventually lead to price increases. It is also difficult to assess the possible effects which price increases would have on the future demand for gas in terms of interfuel competition, since alternative fuels are also experiencing strong upward cost pressures. However, gas is a premium fuel, as well as a nonrenewable commodity; therefore it will demand and likely receive premium prices.

Exports will continue to grow in 1972 because of provisions in existing contracts, but the rate of increase will be below that of recent years. No new applications for export licences were under consideration by the NEB in 1971. Since strong growth is projected in Canadian requirements, the growth in reserves in western Canada will have to substantially exceed that of recent years if sufficient reserves are to be established to again provide surplus gas for export. For the development of northern gas reserves, gas will probably have to be supplied to both the Canadian and United States markets to utilize the capacity of the proposed large-diameter pipelines and to bring the gas from these regions as economically as possible.

During 1972 gas sales in Canada should rise by about 11 per cent to 3,000 MMcf/d. Growth in export sales should moderate somewhat from recent years for an increase of around 10 per cent, or 2,700 MMcf/d, and production will average about 7,700 MMcf/d.

Production

Net withdrawals from gas fields increased by 9.8 per cent in 1971, reaching 2,500,751 MMcf or 6,851 MMcf/d. This growth was substantially less than the high annual increases of 15.1 per cent and 17.0 per cent in the previous two years. More than 83 per cent of total Canadian production came from fields in Alberta. British Columbia accounted for more than 12 per cent of the Canadian total, with the balance coming from four other provinces and the Northwest Territories.

Table 2 shows the amount of gas which was produced and later reinjected into a producing reservoir either as a conservation measure to increase the ultimate recovery of liquid hydrocarbons and sulphur, or as a part of distributors' storage operations. The Kaybob South field is an example of a conservation scheme to maximize ultimate recovery of field gas constituents. Here gas is produced and processed to remove the liquid hydrocarbons and sulphur, after which most of the residue gas is reinjected to maintain pressure in the original producing reservoir. This operation is designed to ensure the maximum possible recovery of natural gas liquids and sulphur before the reservoir is depleted by the sale of residue gas. Similarly, natural gas is reinjected into producing oil reservoirs thereby maintaining reservoir pressure to maximize production of crude oil.

The volumes shown as distributors' storage represent gas which is stored by gas utilities during low-demand periods, usually in summer, and is later withdrawn as required to meet peak demands in winter. This helps to level out the utilities' demand on the trunk carriers over the year. In Alberta and Ontario most of the gas is stored in former producing fields which have been depleted. However, in Saskatchewan much of the storage is in large man-made subsurface caverns which have been leached from salt beds specifically to provide storage facilities near major consuming areas.

Exploration and development

Alberta. Development of new gas reserves continued to make up an important part of the total exploratory and development effort in the province during 1971.

Table 2. Pressure maintenance projects and storage of natural gas in Canada, 1970-71

	1970 Input (Mcf)	1971^p Input (Mcf)
Alberta		
Aerial	185,065	150,003
Ante Creek	1,323,808	1,689,502
Bigstone	1,643,385	496,048
Bonnie Glen	474,011	133,892
Carson Creek	14,138,803	11,336,156
Carstairs	2,343,401	1,421,921
Crossfield	11,157,755	3,862,926
Crossfield East	3,809,176	2,999,418
Duhamel	341,283	221,202
Gilby	359,088	444,570
Golden Spike	8,604,118	8,712,662
Harmattan East	39,464,908	43,542,758
Harmattan-Elkton	33,212,257	36,652,430
Joarcam	1,217,442	1,325,640
Judy Creek	2,239,033	2,392,923
Kaybob South	52,634,093	57,920,108
Leduc-Woodbend	1,128,495	2,035,620
Mitsue	–	171,755
Pembina	2,430,820	2,282,981
Rainbow	12,196,537	11,172,236
Rainbow South	939,125	856,635
Redwater	324,888	564,774
Swan Hills	561,878	2,201,317
Turner Valley	461,924	55,464
Virginia Hills	–	186,345
Waterton	11,814,517	11,626,223
Westerose South	9,889,460	6,119,054
Willesden Green	985,742	1,690,872
Windfall	36,029,217	19,386,106
Wizard Lake	5,168,418	5,699,073
Distributor's storage		
Bow Island	1,945,525	1,791,737
Carbon	3,028,911	4,403,573
Lloydminster	265,552	279,866
Viking-Kinsella	1,021,838	1,583,455
Total (14.65 psia)	261,340,473	245,409,245
Volume (adjusted to 14.73 psia)	259,929,234	244,084,035
Ontario	80,852,342	78,638,635
Saskatchewan (14.73 psia)	6,324,237	5,168,115
Total, Canada (14.73 psia)	347,105,813	327,890,785

Source: Provincial government reports.

^{p}Preliminary; – Nil.

Following the pattern of recent years, many wells were drilled in or near the many producing fields in southeastern and east-central Alberta, an area characterized by relatively shallow drilling depths, easy accessibility and good pipeline connections. Successful gas wells accounted for about one third of all well completions during 1971, but only about one quarter of the total footage.

A large number of wells were again drilled in the Medicine Hat-Alderson area where development of the shallow Upper Cretaceous Milk River sandstones, which has been under way since 1968, is providing substantial gas reserves. Because of the characteristics of the reservoir rock and the low formation pressure, a large number of relatively closely spaced wells are necessary to effectively drain the reservoir. However,

Table 3. Canada, production of natural gas, 1970-71[1]

	1970		1971p	
	(Mcf)	($)	(Mcf)	($)
Gross new production				
New Brunswick	131,160		105,114	
Quebec	165,825		170,168	
Ontario	17,063,893		16,046,550	
Saskatchewan	80,182,765		86,359,977	
Alberta	2,184,366,998		2,362,642,778	
British Columbia	343,123,267		358,121,631	
Northwest Territories	892,630		1,146,137	
Total, Canada	2,625,926,538		2,824,592,355	
Waste and flared				
Saskatchewan	17,576,455		16,530,069	
Alberta	60,770,130		58,379,816	
British Columbia	10,950,546		8,764,355	
Northwest Territories	810,691		857,263	
Total, Canada	90,107,822		84,531,503	
Reinjected				
Saskatchewan	12,243		–	
Alberta	253,089,758		233,794,523	
British Columbia	5,607,924		5,515,481	
Total, Canada	258,709,925		239,310,004	
Net withdrawals				
New Brunswick	131,160	108,011	105,114	59,495
Quebec	165,825	24,874	170,168	25,866
Ontario	17,063,893	6,487,852	16,046,550	6,097,689
Saskatchewan	62,594,067	7,331,962	69,829,908	9,077,888
Alberta	1,870,507,110	265,912,073	2,070,468,439	294,006,518
British Columbia	326,564,797	35,200,442	343,841,795	38,166,439
Northwest Territories	81,939	34,578	288,874	121,038
Total, Canada	2,277,108,791	315,099,792	2,500,750,848	347,554,933
Processing shrinkage				
Saskatchewan	2,149,207		2,200,446	
Alberta	265,726,945		287,838,300	
British Columbia	6,426,898		15,170,202	
Total, Canada	274,303,050		305,208,948	
Net new supply, Canada	2,002,805,741		2,195,541,900	

Source: Statistics Canada. pPreliminary; – Nil. [1]14.73 psia.

new drilling and production practices, pioneered by Alberta Eastern Gas Limited, have made approximately 700 million cubic feet of reserves, which were previously considered nonrecoverable, now available in this area.

Significant new reserves are being proven up in the Dunvegan-Belloy area of west-central Alberta, approximately 55 miles north of Grande Prairie. Anderson Exploration Ltd., as operator for a group of companies, began an exploration and development program in 1970, which has proven up a productive trend approximately 15 miles long and 2 to 3 miles wide in the Dunvegan area. Reserves of 1.2 trillion cubic feet had been proven up by mid-1971, mostly in Mississippian rocks in the Dunvegan area. Financing of this program has been aided by advances of more than $10 million from Alberta and Southern Gas Co. Ltd., which will be repaid when gas production starts. This method of making advances and prepayments to develop new gas reserves has been widely used in recent years, particularly by companies seeking to develop gas for export.

The prospects of very large gas discoveries helped to maintain interest in the Foothills of Alberta, even though exploration and production operations are much more expensive than in the plains area. In particular, the presence of hydrogen sulphide in most of the fields has an adverse effect on the economics of gas exploration in the Foothills, since it must be removed before the gas is marketed. Additionally, the cost of gas processing has increased because of more stringent controls on sulphur emissions from gas plants while, on the other hand, sulphur prices are very low because of a current world oversupply situation. During the year, in an area centered 90 miles northwest of Calgary, successful exploration and development drilling resulted in substantial extensions to the field limits of the Strachan and Ricinus West Devonian gas fields, and the Ricinus Upper Cretaceous Cardium oil and gas field. Five miles south of Ricinus, a new Cardium gas discovery was reported at Am Hess Bearberry 6-20-33-7W5. Farther to the northwest, a Mississippian gas discovery was reported at Ocelot et al Peco 10-35-48-16W5, located between the large Edson and Brazeau River Mississippian gas fields. Triassic gas was reported at Pacific Amoco Tony 10-23-63-21W5, approximately 5 miles northwest of the closest Triassic production in the Kaybob South field.

Table 4. Canada, production, trade and total sales of natural gas, 1961-1971

		Net Withdrawals	Imports	Exports	Sales in Canada
1961	Mcf	634,130,669	5,574,355	168,180,412	370,739,542
	$	72,023,046	1,708,048	41,688,585	226,678,494
1962	Mcf	894,671,614	5,575,466	319,565,908	412,061,509
	$	104,060,533	1,801,912	72,423,312	257,589,445
1963	Mcf	993,388,491	6,877,438	340,953,146	451,598,298
	$	124,458,230	2,356,310	75,630,344	287,584,177
1964	Mcf	1,327,664,338	8,046,365	404,143,095	504,503,380
	$	145,057,536	2,871,145	97,608,555	327,982,720
1965	Mcf	1,442,448,070	15,673,069	403,908,528	573,016,494
	$	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	540,616,566
1970	Mcf	2,277,108,791	11,877,827	768,112,547	917,440,879
	$	315,099,792	5,123,896	205,988,180	582,316,948
1971[p]	Mcf	2,500,750,848	16,010,217	903,051,071	1,001,316,902
	$	347,554,933	7,021,000	250,719,000	641,893,136

Source: Statistics Canada. Figures in Tables 4 and 12 differ for imports and exports because of different reporting procedures and timing.
[p]Preliminary.

Table 5. Canada, liquids and sulphur recovered from natural gas, 1961-71

	Propane	Butane	Condensate/ Pentanes Plus	Sulphur
	(bbl)	(bbl)	(bbl)	(lt)
1961	2,875,823	2,157,309	5,444,034	487,679
1962	3,671,683	2,744,044	10,802,436	1,035,988
1963	4,353,871	3,273,625	21,759,526	1,281,999
1964	7,615,121	5,656,888	25,275,285	1,472,583
1965	10,371,256	6,957,833	27,864,189	1,589,586
1966	12,643,278	8,230,620	29,354,168	1,729,455
1967	14,171,019	9,890,125	30,749,780	2,168,646
1968	15,977,317	10,499,003	33,200,698	3,042,105
1969	17,941,218	11,759,888	37,687,140	3,714,312
1970	21,343,768	13,846,081	43,305,400	4,240,982
1971[p]	24,231,810	15,411,081	45,992,130	4,555,325

Source: Statistics Canada and provincial government reports.
[p]Preliminary.

Other exploratory successes were reported and many existing fields throughout the province were enlarged by development drilling. As a result, at year-end there were 2,830 operating gas wells, out of 3,426 capable of production.

British Columbia. Both the total footage drilled and number of wells completed rose by 6 per cent in 1971. However, both exploratory and development gas well successes were down with the decrease being most marked in the development category, which declined by approximately one third.

A dual zone gas discovery was reported at Home et al Attachie 7-29-84-22W6, 25 miles northeast of Fort St. John, where commercial production was indicated from the Triassic Baldonnel Formation and the Mississippian Kiskatinaw Formation. Further development was undertaken in and near the numerous fields in the general Fort St. John region where production is obtained mainly from reservoirs in Cretaceous, Triassic and Mississippian rocks. New reserves were also developed in several pools in the Fort Nelson area which produce from the Middle Devonian Slave Point Formation. A new Slave Point discovery was indicated at Pacific Sextet c-22-K 35 miles southeast of Fort Nelson. A second discovery in the Slave Point was indicated in the Shekilie area, 100 miles northeast of Fort Nelson at Hubert Quintana et al Shekilie a-74-G.

One well was drilled and abandoned on Graham Island of the Queen Charlotte Islands. There was no offshore drilling during the year. However, during 1971 offshore acreage held by companies under federal permits increased by 1.3 million acres to a total of 16.3 million acres. At the end of 1971, there were 745 gas wells capable of operation in the province, of which 305 were in operation.

Northwest Territories and the Yukon. Drilling in Canada's northern frontier areas, both on the mainland and in the Arctic islands, continued to increase as more companies were attracted by the high success ratio in the early stages of exploration which continued during 1971. On the mainland, interest has focussed on the general Mackenzie Delta area since Imperial Oil Limited made its first oil discovery at Atkinson Point in 1970. Following some unsuccessful wells after this discovery, Imperial was again successful early in 1971 at the IOE Mayogiak P-17 well, located 30 miles to the southwest of Atkinson Point. Oil and gas were reported on tests at 3,800 feet and light gravity oil flowed to surface on later tests at 9,400 feet. Another discovery was indicated in the latter part of 1971 when the company reported the recovery of large volumes of wet gas on tests at a depth of about 8,100 feet at the IOE Taglu G-33 well, located about 50 miles west of Mayogiak on Richards Island. Evidence of significant gas and condensate occurrences was also encountered at IOE Taglu West, 4 miles to the west, and IOE Mallik L-38, 8 miles northeast of Taglu G-33, both of which were drilling at year-end. Although detailed information has not been released, the operator has said that several hundred feet of reservoir beds are present and that the wells are considered to be capable of gas production at high rates, with condensate production also being possible. Drilling in the area is being accelerated to evaluate its reserve potential and, in the shallow delta waters, will include the first experimental use of man-made islands for drilling platforms.

In the Canadian Arctic Archipelago, the widespread exploratory drilling program initiated by Panarctic Oils Ltd. and taken up by other operators

Table 6. Canada, wells drilled, by province, 1970-71

	Oil		Gas		Dry[1]		Total	
	1970	1971	1970	1971	1970	1971	1970	1971
Western Canada								
Alberta	304	361	617	691	903	938	1,824	1,990
Saskatchewan	469	266	63	108	401	367	933	741
British Columbia	36	46	50	36	91	106	177	188
Manitoba	2	2	–	–	17	13	19	15
Yukon and Northwest Territories	1	1	1	3	68	72	70	76
Westcoast offshore	–	–	–	–	–	–	–	–
Hudson Bay offshore	–	–	–	–	–	–	–	–
Subtotal	812	676	731	838	1,480	1,496	3,023	3,010
Eastern Canada								
Ontario	10	2	63	47	96	91	169	140
Quebec	–	–	–	–	4	5	4	5
Atlantic provinces	–	–	–	–	–	–	–	–
East coast offshore	–	–	–	1	14	18	14	19
Subtotal	10	2	63	48	114	114	187	164
Total, Canada	822	678	794	886	1,594	1,610	3,210	3,174

Source: Canadian Petroleum Association.
[1]Includes suspended wells; – Nil.

continued in 1971. In December, at Kristoffer Bay on the west coast of Ellef Ringnes Island, Panarctic Oils, which is the major operator in this area, made its third major Arctic gas discovery. The well, Panarctic Tenneco et al Kristoffer Bay G-06, was reported to have flowed sweet, relatively dry gas on test but actual flow rates have not been released. The new discovery is about 50 miles north of Panarctic's earlier gas success on King Christian Island which was the site of a spectacular fire following its discovery late in 1970. The relief well, which was drilled to kill the fire early in 1971, was completed as a capped gas well with a calculated absolute open flow of 264 MMcf/d, although the actual deliverability of the well on production would be well below this rate. A subsequent development well drilled 2 miles north of the King Christian discovery confirmed the continuation of the producing reservoir to this location. Panarctic and other operators completed additional wells during the year, but without success. To the end of 1971, 41 tests had been drilled or were under way at locations on 16 different Arctic islands, of which all but three have been drilled in the past three years.

The large discoveries in the Arctic have attracted the attention of several United States gas companies, which are providing financial backing for exploration and development in return for the opportunity to obtain new gas supplies. One of the major agreements of this type was entered into between Panarctic and four United States companies in mid-1971. Under this agreement $75 million will be provided to Panarctic over five years for exploratory drilling to locate gas reserves. Additional funds will be made available for development drilling when gas markets are assured. In return, the companies will have priority to purchase any gas developed by the program and declared surplus to Canadian requirements, at a price suitable to Panarctic. The companies will be repaid by Panarctic from revenue received from gas sales and when their capital is repaid, they will earn a 1 per cent working interest in the gas reserves. Somewhat similar agreements for gas reserves in northern Canada were completed or were under consideration by other groups of companies during 1971.

In addition to the industry activity in the far North, exploration is also being conducted in the more southerly regions of the Territories, particularly in geologically favourable areas adjacent to the route which will probably be followed by the proposed pipelines from the Mackenzie Delta and Prudhoe Bay in Alaska. One gas discovery was confirmed at CPOG et at La Biche F-09 in the Fort Liard area, but the well is shut in because of a lack of pipeline facilities. Pipeline connections were completed to allow the first production from the Pointed Mountain field in the southwestern corner of the Northwest Territories.

Table 7. Footage drilled in Canada for oil and gas, by province, 1970-71

	Exploratory		Development		All Wells	
	1970	1971	1970	1971	1970	1971
Alberta	4,451,720	4,300,181	3,325,273	3,585,434	7,776,993	7,885,615
Saskatchewan	1,081,004	1,053,283	1,398,639	954,226	2,479,643	2,007,509
British Columbia	498,881	518,807	401,051	431,488	899,932	950,295
Manitoba	42,709	18,548	12,017	13,880	54,726	32,428
Northwest Territories	361,710	468,016	–	–	361,710	468,016
Westcoast offshore	–	–	–	–	–	–
Hudson Bay offshore	–	–	–	–	–	–
Total, western Canada	6,436,024	6,358,835	5,136,980	4,985,028	11,573,004	11,343,863
Ontario	147,152	134,803	160,990	115,516	308,142	250,319
Quebec	35,757	28,555	–	–	35,757	28,555
Atlantic provinces	–	–	–	–	–	–
Eastcoast offshore	149,220	204,366	–	–	149,220	204,366
Total, eastern Canada	332,129	367,724	160,990	115,516	493,119	483,240
Total, Canada	6,768,153	6,726,559	5,297,970	5,100,544	12,066,123	11,827,103

Source: Canadian Petroleum Association. – Nil.

The total number of wells drilled in the Yukon and Northwest Territories increased from 70 in 1970 to 76 in 1971, while the total footage drilled was up by about 30 per cent. Land under federal permits and leases rose to 469.2 million acres at the end of 1971, from 437.4 million acres in 1970.

Saskatchewan and Manitoba. The number of gas well successes in Saskatchewan increased sharply during 1971, in spite of a 20 per cent decline in both total wells completed and total footage drilled. Most of the increase was in the development category, where successful completions rose from 38 in 1970 to 74 in 1971. Successful exploratory gas wells increased from 25 to 34 in 1971. All of the wells were drilled in west-central and southwestern Saskatchewan, with more than half of the development well completions resulting from expansion of the established Hatton field. Further follow-up drilling is planned for some indicated exploratory successes to determine their importance. At the end of 1971, there were 411 gas wells producing out of 654 capable of production.

In the absence of new discoveries, drilling activity in Manitoba remained at a low level, with only 15 wells being drilled. There are no producing gas wells in the province and Manitoba has never produced commercial gas.

Eastern Canada. The most significant discovery to date in the exploration of eastern Canadian offshore areas was made during 1971 on Sable Island, approximately 190 miles east-southeast of Halifax, Nova Scotia. The well, Mobil Tetco Sable Island E-48, yielded hydrocarbons from 17 different zones which were tested and additional untested zones also appear productive. Twelve zones flowed gas at rates from .7 to 10.6 MMcf/d with condensate at 127 to 1,660 b/d; four other zones flowed crude oil at rates of 127 to 1,660 b/d with associated small gas flows; one zone tested 3.9 to 5.6 MMcf/d of gas. Additional wells will be drilled on the island and in the immediate offshore area to determine if commercial production can be established. This is the most encouraging discovery to date in the 28 wells which have been drilled since 1968 in the region paralleling the Nova Scotia coast. Mobil Oil Canada, Ltd. has drilled three wells, including an earlier unsuccessful attempt on Sable Island. Shell Canada Limited had completed 28 offshore wells to the end of 1971 and has reported several oil and gas occurrences, none of which was considered commercial. At year-end the Mobil-Tetco group had one well under way and Shell was drilling on two locations.

Offshore drilling operations were also carried out in the Grand Banks region southeast of Newfoundland, approximately 375 miles east of the Sable Island discovery. The team of Amoco Canada Petroleum Company Ltd. and Imperial Oil Enterprises Ltd. followed up two earlier attempts in this region with five additional exploratory wells in 1971, and were drilling a sixth at year-end. Elf Oil Exploration and Production Canada Ltd. also completed one well during the year.

The first exploratory drilling attempt off the Labrador coast was made during 1971. One well, Tenneco et al Lief E-38, was drilled to 3,557 feet, but was suspended short of the proposed total depth because of anchoring problems. Operators continued to file on additional land off Labrador and in other offshore areas, raising total acreage under federal permits off the east coast to 318.5 million acres at the end of 1971, up from 281.4 million acres in 1970.

In Ontario, drilling activity continued to decline with both the total number of wells and footage drilled being reduced by about one fifth from the 1970 level. Ten new gas discoveries and 37 successful development gas wells were reported from the established producing region in the southwestern part of the province, compared with six new discoveries and 57 development wells completed in 1970. Continued interest is being shown in the relatively unexplored sedimentary basin in the Hudson Bay area. The Consumers' Gas Company has undertaken a three-year, geophysical and drilling program in the James Bay Lowlands area. At year-end, the company was drilling one well, Consumer #1 Greer, at a location 25 miles southwest of Moosonee, near the mouth of the James River. Aquitaine Company of Canada Ltd., as operator for an eight-company group, drilled one test to 1,945 feet in the Sandbank Lake area, 70 miles to the southwest, but suspended a second test because of technical difficulties. There was no drilling offshore in Hudson Bay during 1971 and companies gave up permits to several large blocks of acreage, reducing land under federal permits in Hudson Bay and Hudson Strait to 85.7 million acres, a substantial reduction from 113.2 million acres in 1970.

Five exploratory wells were completed in Quebec. A small gas show was reported in tests at Shell Ste-Françoise-Romaine #1, 40 miles southwest of Quebec City and drilling was continuing at the well at year-end. Husky Oil Ltd. completed a two-well exploratory program in the Trois-Rivières area, and other wells were drilled near Baieville and on the Île d'Orléans near Quebec City.

Reserves

Annual estimates made by the Canadian Petroleum Association (CPA) show that proved remaining marketable reserves of natural gas in Canada amounted to 55,461,850 MMcf at the end of 1971. This is an increase of 2,086,222 MMcf, or 3.9 per cent during the past year and represents an improvement over the 2.7 per cent increase attained in 1971. Extensions to existing pools resulted in additions to reserves of 2,280,205 MMcf, while revisions and new discoveries added a total of 1,659,056 MMcf. Offsetting these increases were net production, estimated at 1,953,104 MMcf by the CPA, and a slight increase in underground storage. Since 1961, net increases have averaged 2,592,588 MMcf each year, ranging from a high of 6,327,292 MMcf during 1964 to a low of 1,034,983 MMcf in 1965. Over this same period, total remaining reserves have continued to rise from the total of 29,535,998 MMcf at the end of 1961, although the estimated production rate in 1971 was almost three times the 1961 level of 693,675 MMcf.

Reserves in Alberta rose more than 4 per cent in 1971, after having remained essentially the same in1970. Reserve estimates for the Northwest Territories were also increased by revisions and extensions to existing fields in the southwestern area. No allowance has yet been made for the discoveries in the Mackenzie Delta or the Arctic islands. British Columbia showed a very slight decline in total reserves during 1971, while reserves in Saskatchewan and Ontario dropped 4 per cent and 6 per cent, respectively.

Table 8. Canada, estimated year-end marketable reserves of natural gas, 1970-71

	1970	1971
	(millions of cubic feet)	
Alberta	41,607,827	43,415,155
British Columbia	9,626,692	9,614,625
Saskatchewan	844,213	812,727
Eastern Canada	290,598	273,045
Northwest Territories	1,006,298	1,346,298
Total	53,375,628	55,461,850

Source: Canadian Petroleum Association.

Natural gas processing

New processing capacity coming on stream in 1971 amounted to 2,477 MMcf/d, the greatest annual increase in the history of the Canadian gas processing industry. The completion of five large new plants and major expansions at three existing plants accounted for most of the record increase. As a result, total input gas capacity of Canadian plants is now 13,100 MMcf/d. Potential natural gas liquids production is 105,792 b/d of propane, 57,319 b/d of butane and 189,439 b/d of pentanes plus. Sulphur producing capacity is rated at 17,757 long tons daily. The total possible output of residue gas is 10,956 MMcf/d, of which 10,406 MMcf/d would be available for commercial consumption. The balance would be reinjected into producing reservoirs as part of enhanced recovery projects. Although a major expansion of processing capacity is under way in northern British Columbia, most gas processing capacity is concentrated in Alberta. At the end of 1971, Alberta accounted for more than 88 per cent of the gas processing capacity, 99 per cent of the liquid recovery capacity and 98 per cent of the sulphur recovery capacity in Canada.

An important addition to processing capability in 1971 resulted from the completion of a 1,500 MMcf/d gas reprocessing plant built by Dome Petroleum Limited at Empress, Alberta. It is located at the eastern terminus of The Alberta Gas Trunk Line Company system and is designed to remove additional natural gas liquids from gas which was initially treated in field processing plants. This is the third such plant in Alberta. Pacific Petroleums, Ltd. has operated a 1,500 MMcf/d plant at Empress since 1964 and

Table 9. Canada, natural gas processing plant capacities, by fields, 1971

Main Fields Served	Raw Gas Capacity	Residue Gas Produced
	(million cf/day)	
Alberta		
Acheson	6	5
Alexander, Calahoo	36	35
Bigoray	13	12
Bigstone	48	36
Black Butte	10	10
Bonnie Glen	48	40
Boundary Lake South	25	22
Brazeau River	104	96
Brazeau South	66	60
Burnt Timber	54	45
Calling Lake	15	15
Carbon	155	150
Caroline (2 plants)	53	45
Carson Creek	100	48
Carstairs	334	280
Cessford (4 plants)	190	184
Cessford North (2 plants)	21	20
Chigwell (2 plants)	12	10
Connorsville, Cessford	5	5
Countess	22	21
Crossfield (2 plants)	319	218
East Crossfield	146	87
Edson	377	339
Enchant	5	5
Equity, Ghost Pine	16	15
Ferrier	110	94
Ferrier South	20	19
Figure Lake	12	12
Ghost Pine	113	111
Gilby (6 plants)	108	97
Gilby North	19	18
Gold Creek	60	40
Golden Spike	45	reinj.
Greencourt	30	28
Harmattan-Elkton (2 plants)	288	15
Harmattan-Elkton South	5	4
Homeglen-Rimbey	422	357
Hussar	80	75
Innisfail	15	10
Judy Creek, Swan Hills (2 plants)	210	142
Jumping Pound	250	200
Kaybob	95	92
Kaybob South	382	57
Kessler	6	5
Keystone	8	7
Lac la Biche	25	25
Leduc-Woodbend	35	31
Lone Pine Creek	51	41
Marten Hills	133	130
Marten Hills South	24	24
Mikwan North	15	13
Minnehik-Buck Lake	108	100
Mitsue	21	15
Morinville, St. Albert	22	20
Nevis Stettler (2 plants)	170	139
Okotoks	30	13
Olds	100	76
Oyen	3	3
Paddle River	30	28
Pembina (12 plants)	152	129
Pincher Creek	204	145
Prevo	5	4
Princess (2 plants)	15	15
Provost (4 plants)	127	120
Quirk Creek	90	68
Rainbow Lake (2 plants)	44	reinj.
Redwater	22	8
Retlaw	7	7
Savanna Creek	75	63
Sedalia	5	5
Sibbald	6	5
Simonette	15	11
South Lone Pine Creek	30	22
Strachan D-3	250	201
Sturgeon Lake South	12	9
Swalwell	4	4
Sylvan Lake (2 plants)	91	82
Three Hills Creek	10	9
Turner Valley	45	37
Ukalta	6	6
Virginia Hills	12	10
Vulcan	25	22
Warwick	9	9
Waskahigan	16	12
Waterton	468	311
Wayne-Rosedale	27	24
Wildcat Hills	112	95
Willesden Green	2	11
Wilson Creek	15	10
Wimborne	60	46
Windfall, Pine Creek	215	132
Wood River	5	5
Worsley	23	21
Pipeline at Ellerslie[1]	70	66
Pipeline at Empress[2] (2 plants)	3,000	2,892
Pipeline at Cochrane[3]	1,000	970
Saskatchewan		
Cantuar	25	24
Coleville, Smiley	52	51
Dollard	2	2
Milton	4	4

Table 9 (cont'd)

Main Fields Served	Raw Gas Capacity	Residue Gas Produced
	(million cf/day)	
Smiley	4	3
Steelman	38	30
West Gull Lake	15	14
British Columbia		
Beaver River	240	240
Boundary Lake (2 plants)	29	27
Clarke Lake	530	440
Fort St. John	500	440
Ontario		
Becher	1	1
Corunna (2 plants)	5	5
Port Alma	16	16

Source: Natural Gas Processing Plants in Canada (Operators List 7), January 1972, *Department of Energy, Mines and Resources.*
[1]Plant reprocesses gas owned by Northwestern Utilities, Limited. [2]Plants reprocess gas owned by TransCanada Pipe Lines Limited. [3]Plant reprocesses gas owned by exporting companies.

Alberta Natural Gas Company Ltd. began operation at a similar plant at Cochrane in 1970. Output of the Dome plant is 1,432 MMcf/d of residue gas and a mixed stream of LPG and pentanes plus. The mixed stream of natural gas liquids is shipped by pipeline, along with liquids from the Cochrane plant and others in Alberta, to a new fractionation plant operated by Dome in Sarnia, Ontario, where the products are separated. Capacity of the Sarnia fractionation plant is 24,800 b/d of propane, 13,500 b/d of butane, and 26,700 b/d of pentanes plus, of which 11,300 b/d of propane, 5,500 b/d of butane and 2,000 b/d of pentanes plus would come from Dome's Empress plant.

Other major new facilities put on stream during the year included the new Gulf Oil Canada Limited plant in the Strachan field, 90 miles northwest of Calgary. This plant has a capacity of 250 MMcf/d of raw gas and 201 MMcf/d of residue gas, 6,230 b/d of pentanes plus and 842 lt/d of sulphur. Shell Canada Limited, twinned its existing plant in the Waterton area of southwestern Alberta, increasing raw gas capacity by 210 MMcf/d to 468 MMcf/d and raising liquid capacity to 1,600 b/d of propane, 1,100 b/d of butane and 31,900 b/d of pentanes plus with 2,930 lt/d of sulphur. In the Quirk field, 20 miles southwest of Calgary, Imperial Oil Limited began operating a new plant having a raw gas capacity of 90 MMcf/d and residue gas capacity of 68 MMcf/d, which can produce 4,000 b/d of pentanes plus and 240 lt/d of sulphur. Imperial also expanded the raw gas capacity of the Judy Creek plant from 85 MMcf/d to 175 MMcf/d. Plant expansion was also undertaken by CanDel Oil Ltd. at its Buck Lake plant, increasing raw gas capacity by 38 MMcf/d to 108 MMcf/d and increasing recovery of natural gas liquids and sulphur. Hudson's Bay Oil and Gas Company Limited began recovery of 6,000 b/d of mixed LPG at its Kaybob South plant No. 2 in the fall of the year. Elsewhere in Alberta smaller plants were completed at Lone Pine Creek, Bigoray, Pembina, Hope Creek and Delburne. Plant expansions were also completed at Brazeau South, Wayne Dalum, Redwater and Willesden Green.

In British Columbia, Westcoast Transmission Company Limited continued to expand its gas processing capability to meet new requirements. Expansion of the Fort Nelson plant is under way, which will raise raw gas capacity to 1,100 MMcf/d by September, 1972. Amoco Canada Petroleum Company Ltd. has completed a 240 MMcf/d plant in the Beaver River field on the Yukon-B.C. border, and is building the first plant in the Northwest Territories in the Pointed Mountain field. These plants will only dehydrate gas from these fields before it is transported to Fort Nelson for removal of the hydrogen sulphide in the gas.

Significant additions to capacity in Canada should again be made in 1972 as several large new plants and plant expansion projects, under way at the end of 1971, are completed. However, it appears likely that the development of new processing capacity will moderate considerably in coming years because of the lack of large new sour gas discoveries which have created the requirement for large sour gas processing plants in the Foothills in recent years.

Transportation

Pipeline companies continued to expand the natural gas pipeline system in Canada in 1971, by adding more than 2,000 miles of new pipeline and constructing new compressor facilities. Construction was concentrated mainly in the major producing areas in Alberta and British Columbia and in the connecting transmission lines which transport the gas to Canadian and United States markets.

In British Columbia, Westcoast Transmission Company Limited continued to develop new system capacity required to meet growing domestic requirements as well as new export commitments approved by the NEB in 1970. Much of the expansion consisted of looping the main line at 13 locations in central British Columbia, with a total of 234 miles of 36-inch pipe. The Westcoast system was also extended northward with a 112-mile, 24-inch line from Fort Nelson to connect with the Beaver River pool on the British Columbia-Yukon border. An additional northward extension of 34 miles of 20-inch pipeline to tie in the

Table 10. Gas pipeline mileage in Canada, 1967-71

	1967	1968	1969	1970	1971^p
Gathering					
New Brunswick	6	6	6	6	6
Quebec	1	1	1	1	1
Ontario	1,163	1,142	1,193	1,240	1,240
Saskatchewan	714	794	805	893	893
Alberta	2,979	3,350	3,663	4,049	4,440
British Columbia	513	611	650	718	734
Total	5,376	5,904	6,318	6,907	7,314
Transmission					
New Brunswick	14	13	13	13	13
Quebec	121	148	148	148	148
Ontario	3,558	3,518	3,612	3,612	3,622
Manitoba	1,022	1,146	1,227	1,275	1,275
Saskatchewan	3,911	4,332	4,504	4,990	5,250
Alberta	5,327	5,620	6,054	6,575	6,855
British Columbia	1,660	1,758	2,371	2,372	2,917
Total	15,613	16,535	17,929	18,985	20,080
Distribution					
New Brunswick	32	32	32	32	32
Quebec	1,417	1,487	1,572	1,568	1,628
Ontario	13,737	14,497	15,058	15,610	15,889
Manitoba	1,443	1,522	1,466	1,513	1,543
Saskatchewan	1,914	2,031	2,126	2,236	2,355
Alberta	4,296	5,781	6,721	7,553	7,942
British Columbia	4,466	4,610	5,004	5,197	5,250
Total	27,305	29,960	31,979	33,709	34,639
Total, Canada	48,294	52,399	56,226	59,601	62,033

Source: Statistics Canada. ^{p}Preliminary.

Pointed Mountain field in the Northwest Territories was scheduled for completion early in 1972. Inland Natural Gas Co. Ltd. which receives gas supplies from Westcoast, constructed 42 miles of 12-inch loop on its main line between Kingsville and Princeton in south-central British Columbia, and extended a new 56-mile, 12-inch line from Princeton to Oliver. In the south-eastern corner of the province, Columbia Natural Gas Limited built a 39-mile line to the Kaiser Fording Mountain mine development.

Trans-Canada Pipe Lines Limited completed its third line between the Alberta border and Winnipeg with the installation of 39 miles of 36-inch pipe, and began a fourth line with the installation of 138 miles of 42-inch pipe, the first pipe of this diameter to be used in the Trans-Canada system. Preliminary work was also begun on an initial 1972 program involving 92 miles of 42-inch pipe in Saskatchewan and Manitoba, 387 miles of 36-inch line east of Winnipeg and in northern Ontario, and 10 miles of 24-inch pipeline between Toronto and Montreal. However, because of unusually large anticipated market requirements in 1973, application was made to the NEB late in 1971 for approval of an expanded program during 1972 and 1973 requiring the construction of 310 miles of 42-inch pipeline in Saskatchewan and Manitoba, 624 miles of 36-inch pipeline east of Winnipeg and in northern Ontario, and 49 miles of 24-inch line between Toronto and Montreal, together with additional compressor capacity.

Within Alberta, production and transmission companies continued to develop the integrated network of gathering and transmission lines which is required to move gas from the producing fields to the main out-of-province transmission lines. The Alberta Gas Trunk Line Company looped sections of its existing system and connected some new fields and gas plants throughout the province, requiring a total of 247 miles of new line, including 74 miles of 42-inch pipe. Work also began to convert a 297-mile, 20-inch oil pipeline from the Zama Lake area in northwestern Alberta to natural gas service. The line was purchased from Peace River Oil Pipe Line Co. Ltd. by Alberta Gas Trunk and was expected to be in operation in the spring of 1972. Substantial mileage of pipeline was added to field gathering systems which included, for example, more than 100 miles of pipeline installed by Chevron Standard Limited in the Kaybob South field. Throughout Canada, natural gas service was provided to many new customers by the continuing extension of distribution systems into new areas.

Investigations are continuing both in industry and government on a wide variety of problems related to the construction of gas pipelines in the northern areas of Canada. Separate proposals for a gas pipeline have been made by Gas Arctic Systems Study Group, the Northwest Project Study Group and Mountain Pacific Pipeline Ltd., each of which is composed of Canadian and United States companies involved in gas transmission and marketing. In the studies presently under way, particular attention is being given to identifying potential sources of ecological damage and to developing methods to minimize disruption of the environment during the construction and operation of an Arctic pipeline. In order to gain actual operating experience under northern conditions, Gas Arctic and the Northwest Project have each constructed test sections of pipeline at experimental sites in the Northwest Territories. The first pipeline will probably be built in a transportation corridor following the Mackenzie River valley to carry gas from the Mackenzie Delta and from the Prudhoe Bay region on the Alaskan north slope. Alternative routes are under consideration to bring gas from the new discoveries in the eastern Arctic to market, either through a tie-in to the Mackenzie Valley line to the southwest or a separate, more direct line, following a route south along either the east or the west shore of Hudson's Bay. Present indications are that the first application for a northern line may be before the NEB early in 1973.

Markets and trade

Sales of gas to Canadian consumers rose by 9.1 per cent in 1971 to 2,743 MMcf/d, surpassing the 8.8 per cent gain achieved in 1970. Virtually all of this gas is of Canadian origin since imports of United States gas into Canada amounted to only 39 MMcf/d in 1971. Exports to the United States, however, reached 2,495 MMcf/d, an increase of 16.8 per cent, as exporting companies increased shipments under NEB approval granted in 1970.

Almost two thirds of the 1971 increase in Canadian consumption resulted from higher demands of customers in the industrial sector. Industrial sales rose by 11 per cent to 1,489 MMcf/d and now account for about 54 per cent of all gas sales in Canada. Commercial sales also rose by 11 per cent to 567 MMcf/d, equivalent to 21 per cent of total Canadian sales, while residential consumption increased by 4 per cent to 687 MMcf/d. Total revenue from all three categories amounted to almost $642 million, comprised of $234 million from industrial sales, $150 million from commercial sales, and $258 million from residential sales.

On a provincial basis, increased sales in Ontario were responsible for almost two thirds of the total Canadian increase in 1971. Sales in the province rose by 13.2 per cent to 1,259 MMcf/d and made up 46 per cent of the Canadian total. Increased consumption in

Table 11. Canada, sales of natural gas by province, 1971[p]

	Mcf	$	Average $/Mcf	Number of Customers Dec. 31/71
New Brunswick	70,304	180,878	2.57	1,355
Quebec	55,397,098	52,679,647	0.95	207,952
Ontario	459,531,996	353,897,401	0.77	858,576
Manitoba	54,902,911	35,481,175	0.65	135,326
Saskatchewan	82,098,181	39,762,872	0.48	151,608
Alberta	248,416,671	81,422,656	0.33	335,883
British Columbia	100,899,741	78,468,507	0.78	267,334
Total, Canada	1,001,316,902	641,893,136	0.64	1,958,034
Previous totals				
1967	698,223,437	454,722,005	0.65	1,689,157
1968	765,786,814	490,767,434	0.64	1,767,010
1969	844,713,385	540,616,566	0.64	1,767,010
1970	917,440,879	582,316,948	0.63	1,889,808

Source: Statistics Canada. [p]Preliminary.

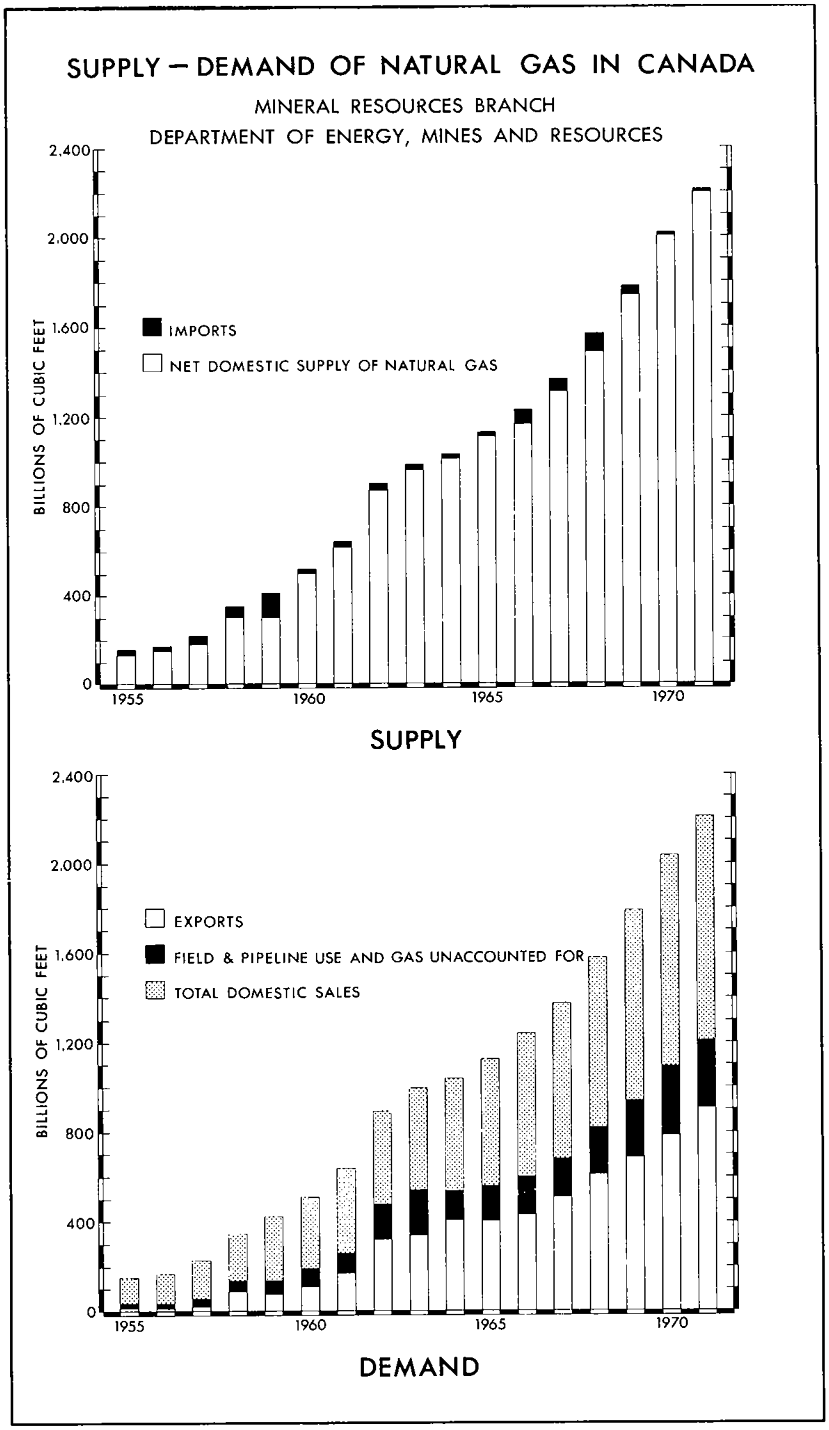

SUPPLY — DEMAND OF NATURAL GAS IN CANADA
MINERAL RESOURCES BRANCH
DEPARTMENT OF ENERGY, MINES AND RESOURCES
BILLIONS OF CUBIC FEET
2,400
2,000
1,600
1,200
800
400
0
IMPORTS
NET DOMESTIC SUPPLY OF NATURAL GAS
1955
1960
1965
1970
SUPPLY
EXPORTS
FIELD & PIPELINE USE AND GAS UNACCOUNTED FOR
TOTAL DOMESTIC SALES
DEMAND

Table 12. Canada, supply and demand of natural gas

	1970		1971^{p}	
	(MMcf)	(MMcf)	(MMcf)	(MMcf)
Supply				
Gross new production		2,625,927		2,824,592
Field waste and flared		−90,108		−84,531
Reinjected		−258,710		−239,310
Net withdrawals		2,277,109		2,500,751
Processing shrinkage		−274,303		−305,209
Net new supply		2,002,806		2,195,542
Removed from storage	70,359		96,593	
Placed in storage	−93,088		−92,912	
Net storage		−22,729		+3,681
Total net domestic supply		1,980,077		2,199,223
Imports		10,860		14,349
Total supply		1,990,937		2,213,572
Demand				
Exports		779,487		910,778
Domestic sales				
Residential	241,793		250,781	
Industrial	489,503		543,614	
Commercial	186,145		206,922	
		917,441		1,001,317
Field and pipeline use				
In production	155,951		164,945	
Pipeline	116,800		119,709	
Other	19,757		13,514	
Line pack changes	7,101		3,704	
Total field and pipeline use		299,609		301,872
Gas unaccounted for		−5,600		−395
Total demand		1,990,937		2,213,572
Total domestic demand		1,211,450		1,302,794
Average daily demand		3,319		3,569

Source: Statistics Canada and provincial government reports.
^{p}Preliminary.

Alberta raised sales by 6.8 per cent to 681 MMcf/d, which represented 25 per cent of all sales in Canada during 1971. Consumption rose in all other provinces having natural gas service, with increases ranging from 4 to 9 per cent.

Meeting the rapid growth in demand for Canadian gas in both domestic and export markets has posed many challenges for producers, transportation and utility companies, and regulatory bodies in Canada. To supply the transportation facilities necessary to meet these increased demands, Trans-Canada undertook a large expansion program for the years 1971-72, involving the installation of several hundred miles of new line and new compressor capacity. In order to provide a better financial structure, Trans-Canada had applied to the NEB to establish a rate base and rate of return for the company and to establish a new rate schedule. Hearings were held during 1971, and early in January 1972 the NEB gave a decision fixing the rate base for 1970, the test period, and indicating that a rate of return of 9 per cent on the rate base was fair and reasonable. Trans-Canada has now filed new rate schedules for approval with NEB to achieve the permitted rate of return. As an interim measure to finance the needed 1972 construction program until the new rates are approved, Trans-Canada and its three major utility customers in Ontario agreed to a price increase of 2.1¢/Mcf effective January 1, 1972. Trans-Canada has reassessed its requirement for new facilities in view of the unusually strong increase in demand anticipated for 1973. As a result, the company filed a new application for a major expansion of the system during 1972 and 1973, which was under consideration by the NEB at the end of 1971.

The accurate assessment of future Canadian gas requirements has become increasingly important because of the strong export demands on Canadian gas in recent years. When considering applications for gas exports from Canada, the NEB assesses reasonable future Canadian requirements, existing reserves, the recent historical trends in finding new reserves and existing export commitments, to determine if any surplus gas is available for export. In 1970 the NEB had approved additional exports for four companies. However, the estimated amount of the exportable surplus at the time was not sufficient to cover all contracts; therefore, the volumes approved for three of the companies were less than the amounts applied for and a fifth application was rejected. In 1971, three of the companies, Alberta and Southern Gas Co. Ltd., Canadian-Montana Gas Company Limited, and Consolidated Natural Gas Limited, again applied for approval to export a total of 2.66 trillion cubic feet over 20 years. Before considering these individual applications, the NEB held public hearings to determine if there was surplus Canadian gas available based on the considerations outlined previously. In November the NEB announced that no surplus gas was available and the three applications were rejected without detailed consideration. In calculating Canadian reserves, no allowance was made for new discoveries in the frontier areas, since these are considered beyond economic reach at present.

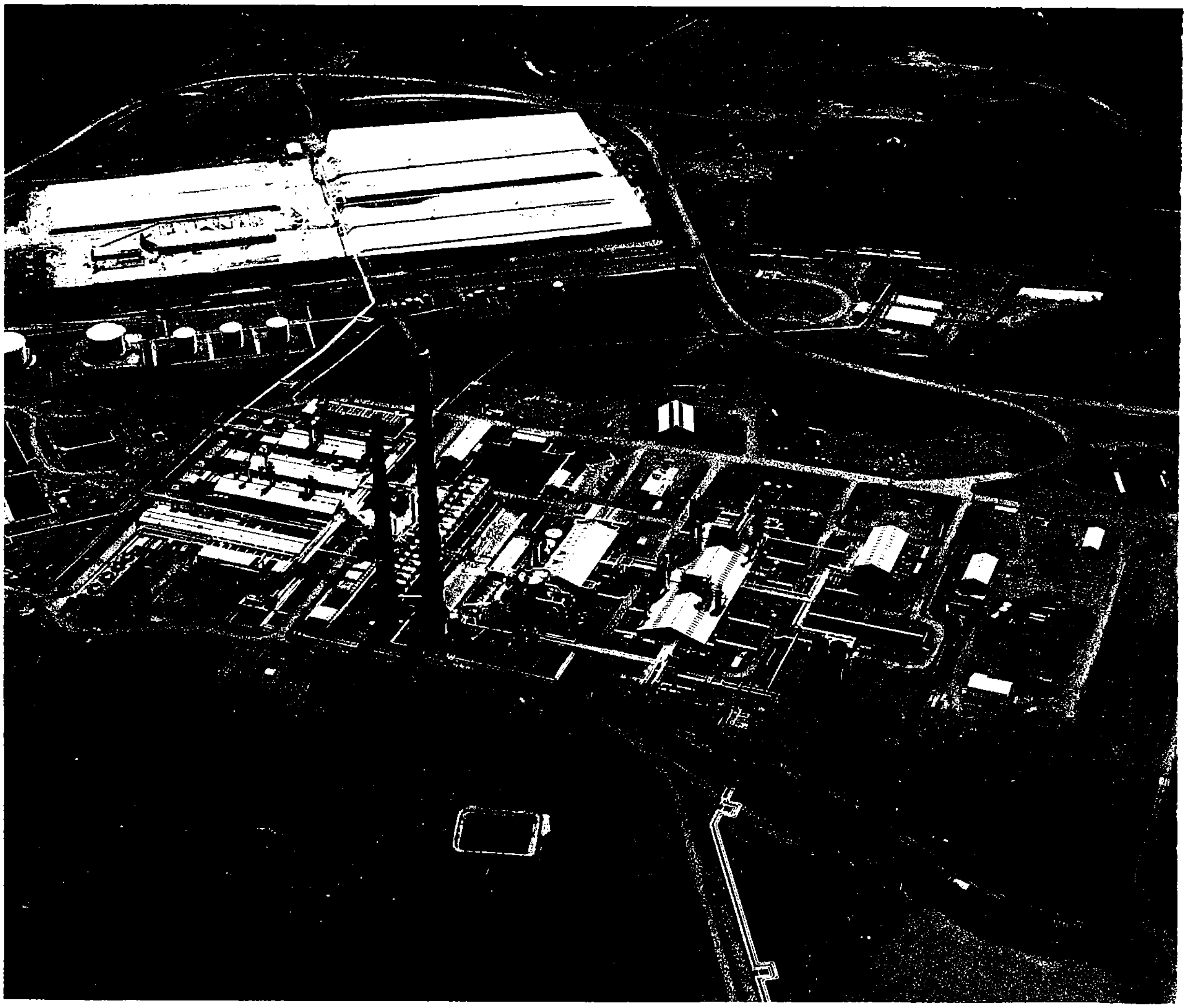
Sectors of the gas industry supporting the export proposals were disappointed with the NEB decision, since the evidence presented in the industry export applications had indicated the availability of surplus gas for export. However, there were substantial differences between the estimates made by the NEB and those of industry for proved Canadian reserves, future Canadian requirements and future pipeline requirements. One of the major areas of concern expressed by industry was the effect the decision might have on the flow of funds needed to ensure a continuing and increasing effort to find additional gas resources.

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 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 most important use of natural gas is as a fuel for space and water heating. Gas is now extensively used in cooking and is becoming common as a fuel for air conditioners, incinerators, dishwashers and laundry equipment. In industrial areas, such as southwestern Ontario, natural gas has been a boon to such industries as automobile plants, steel plants, metal-working firms, glass factories and food-processing industries. For example, in metallurgical processing, the clean, easily controlled flame of natural gas enables the desired temperatures to be attained in rolling, shaping, drawing and tempering steel. The constituents of natural gas have become major sources of raw material for the petrochemical industry. Ethane, seldom removed from natural gas at the field processing plant, is an important petrochemical feed-stock that is sometimes recovered from pipeline gas. 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 gas fuel-cells and power-generator systems driven by gas turbines. Canada has recently become one of the world's largest producers of elemental sulphur, a byproduct recovered in the processing of sour gas (hydrogen sulphide bearing) from fields in western Canada.



An aerial view of Shell Canada's Waterton gas and sulphur plant at Waterton, Alberta. Daily production capacity is 311 million cubic feet of sales gas, 34,000 barrels of natural gas liquids and 2,930 long tons of sulphur (stockpile upper left). (Courtesy of Shell Canada Limited.)

Nepheline Syenite and Feldspar

G. H. K. PEARSE

Nepheline syenite is a white to whitish-grey, medium-grained igneous rock resembling granite in texture and consisting of nepheline, potash and soda feldspars, 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 in which iron-bearing accessory minerals can readily be removed; its major uses are in the glass and ceramics industries.

Nepheline syenite as an industrial raw material was first developed in Canada, and for many years Canada was the world's sole producer. Although the U.S.S.R. began mining nepheline syenite on the Kola Peninsula during the 1930's, the deposit was worked for its phosphate content. Byproduct nepheline syenite from the Kola deposit became important as a source of aluminum and is still being used for this purpose.

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, some 40 years after the original staking, two mills are in operation on Blue Mountain processing rock from three quarries to produce by far the majority of nepheline syenite consumed in the world. In addition to Canada and the U.S.S.R., only one other country, Norway, produces nepheline syenite.

Over the years, glass manufacturers have attempted to reduce the wear in tank furnaces while at the same time improve the quality and yield of the glass batch. One material in particular, nepheline syenite, has probably done more toward this end than all others and over the past 30 years has become a desirable ingredient in glass manufacture. Nepheline syenite is an excellent source of alumina and in addition lowers the melting temperature, thus economizing on fuel consumption and lengthening the life of furnace refractories. Further, nepheline syenite absorbs considerable amounts of additional silica during melting and so contributes towards the speed of melting.

Industrial uses for nepheline syenite other than glass manufacture are many and markets are expanding rapidly in ceramics, enamels, and as a filler in paints, papers, plastics and foam rubber.

Canadian production and developments

Production originates from two operations on Blue Mountain, in Methuen Township, Peterborough County, Ontario. The deposit is pear-shaped, approximately 5 miles long and up to 1.5 miles wide. The iron content of the rock is distributed quite uniformly, but nonetheless, selective quarrying, blending of quarry material and careful pit development are necessary to ensure a mill product capable of meeting rigid 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 at Nephton, Ontario was originally worked by its predecessor Canadian Nepheline,

Table 1. Canada, nepheline syenite production, exports and consumption, 1970-71

	1970		1971^p	
	(short tons)	($)	(short tons)	($)
Production (shipments)	486,667	5,801,228	500,000	6,000,000
Exports				
United States	365,050	4,620,000	386,450	4,860,000
Australia	3,795	87,000	5,224	107,000
Britain	5,259	78,000	2,568	51,000
Puerto Rico	3,200	46,000	1,908	31,000
Venezuela	283	7,000	2,041	25,000
Italy	2,312	57,000	955	22,000
Greece	1,435	28,000	792	20,000
West Germany	619	15,000	649	18,000
Other countries	5,994	125,000	3,653	95,000
Total	387,947	5,063,000	404,240	5,229,000
Consumption[1] (available data)	1969		1970^p	
Glass and glass fibre	54,809		58,592	
Whiteware	10,051		9,719	
Mineral wool	9,784^r		9,800^e	
Porcelain enamel	467		252	
Paints	894		1,472	
Other[2]	2,309		3,525	
Total	78,314^r		83,360	

Source: Statistics Canada.
[1]Adjusted – total and breakdown from Mineral Resources Branch. [2]Includes miscellaneous chemicals, gypsum products, rubber products, cleansers and detergents and other minor uses.
^{p}Preliminary; ^{r}Revised; ^{e}Estimated.

Limited. Ore is mined from two open pits, Cabin Ridge and Craig. Rock is blasted from the pit face and loaded by electric shovels into trucks for haulage to an adjacent 1,000-ton-a-day mill at Nephton. The mill, built in 1956, operates three shifts a day, seven days a week producing a number of grades of nepheline 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 to Havelock, Ontario, some 18 miles south of the mill. From there transportation is by rail to domestic and export markets. Exports to the United States account for about 65 per cent of sales.

International Minerals & Chemical Corporation (Canada) Limited (IMC (Canada)) operates a mill on the Blue Mountain deposit, about 4 miles east of the Indusmin operation. The mill, capable of producing some 600 tons a day of finished product, was constructed in mid-1956 on a portion of the deposit originally staked in 1932 by the Canadian Flint and Spar Company, Limited. 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 and reserves are sufficient for many years. A certain degree of blending from various portions of the pit is required to ensure an acceptable mill feed.

Production is railed to Havelock for distribution to various markets, approximately 90 per cent of the product being exported to the United States. IMC (Canada) produces three grades of nepheline syenite for glass, ceramic, enamel, fibre and other applications.

In 1971 total Canadian shipments amounted to 500,000 short tons valued at $6 million, representing a slight increase in tonnage compared with 1970 (486,667 short tons). Revenue from sales showed a corresponding minor increase over 1970.

In the period 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 development was due in large part to recognition by glassmakers of the superior properties, consistent quality, long-term reliable supply and low cost of nepheline syenite compared with feldspar. Sales were especially bouyant in 1968-69 because of a temporary tight supply situation for feldspar in the United States. Upon a return to more normal feldspar supply conditions in 1970 a minor decrease in nepheline syenite shipments occurred.

Other domestic occurrences

Nepheline syenite is known to occur in many localities in Canada, but to date, only the Blue Mountain deposit can be beneficiated economically to produce material suitable for the glass and ceramic markets. Other occurrences are either too high in iron content or are 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 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 vicinity of The Big Bend 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.

Markets

In 1971, 81 per cent of Canada's nepheline syenite output was exported. Sales to the United States increased 10.6 per cent from 1970 and accounted for 95 per cent of total exports. However, except for Australia and Venezuela, offshore markets continued to diminish sharply, down more than 50 per cent from the record high of 39,000 tons in 1965. This is attributable to capture of European markets by Norwegian nepheline syenite exports. Domestic shipments declined 3 per cent from 1970 to an estimated 95,800 tons because of prolonged strikes in the glass container industry. In total, shipments increased marginally to 500,000 tons in 1971 from the previous year's 486,667 tons.

Canadian consumption normally accounts for approximately 20 per cent of producers' shipments and of this, 70 per cent is used in glass and glass fibre manufacture. Available data for 1969 and 1970, indicate an increase of 7 per cent in consumption for glass and glass fibre, little change in whiteware and mineral wool manufacture and a substantial expansion in use as a filler in paints, plastics and other applications.

Table 2. Canada, nepheline syenite production and exports, 1962-71

	Production[1]	Exports
	(short tons)	
1962	254,418	193,658
1963	254,000	203,262
1964	290,300	226,971
1965	339,982	247,200
1966	366,696	263,624
1967	401,601	307,613
1968	426,595	323,182
1969	500,571[r]	395,613
1970	486,667	387,947
1971[p]	500,000	404,240

Source: Statistics Canada.
[1] Producers' shipments.
[p] Preliminary; [r] Revised.

For use in the glass industry, about 15 to 20 per cent by weight of the glass batch is nepheline syenite. Material with a size range minus 30 mesh-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 analyses of 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. Some products utilizing this material include bathroom fixtures, vitreous enamels for appliances, china, ovenware, electrical porcelain and ceramic artwares.

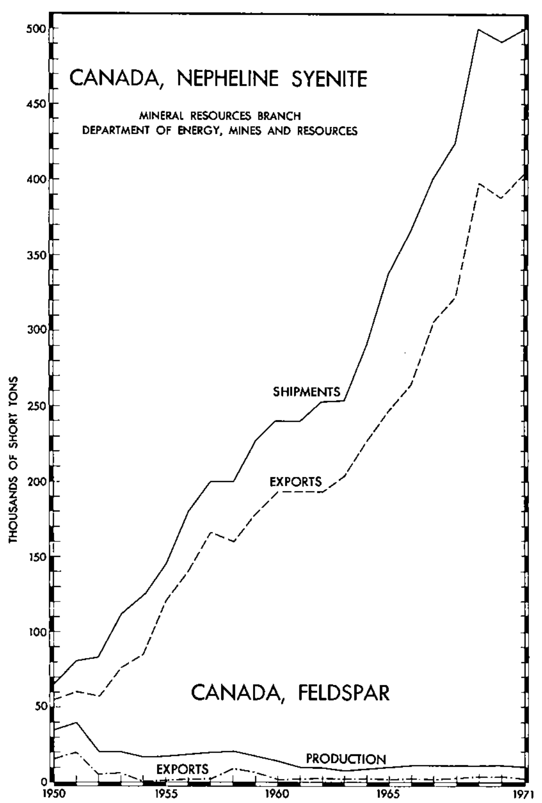
Very finely ground material is being increasingly used as a filler in plastics, foam rubber and paints. Fine-grinding down to 10 microns is accomplished in pebble and fluid-energy mills. The very fine grain size, high reflectance and low oil absorption are important physical characteristics which make nepheline syenite an excellent filler material in such finished products as paints, vinyl furniture upholstery, foam rubber cushions, foam rubber carpet backings, 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 high-iron content material is used in the manufacture of mineral wool and as an aggregate.

World review

The Norsk Nefelin Division of Christiania Spigerwerk is western Europe's only producer of nepheline syenite. Production began in 1961 and increased steadily from 23,000 metric tons in 1963 to 80,000 metric tons in 1968. Operations at the plant near Hammerfest in northern Norway have recently been expanded and capacity in 1971 was 175,000 metric tons per year. Exports for the year are reportedly 150,000 metric tons. The lenticular deposit is over 1 mile in length and extends to a depth of at least 750 feet. 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. New loading facilities are speeding shipments and the loading rate is 1,000 tons an hour.

Nepheline syenite is an important source of alumina for aluminum production in the Soviet Union. Very large deposits occur near Kirovsk in the Kola Peninsula and also in the Lake Baikel region of Siberia. The Kola deposits were first mined in the 1930's for phosphate. Byproduct nepheline syenite 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 syenite and the mix is treated to yield anhydrous alumina, soda, potash and cement.



Outlook

The outlook for nepheline syenite remains good. Prolonged labour disputes in domestic consumer industries which hampered domestic sales volume in 1971 have been settled. European markets will continue to be eroded by expansions of Norwegian nepheline syenite exports. However, these account for less than 5 per cent of Canada's total sales and therefore will have little effect on over-all developments in the industry.

The market for finely ground material used in the ceramic industry and as filler in plastics, paint, rubber, paper, etc., has grown more rapidly than consumption for glass making and further diversification and growth of these markets is expected.

The phenomenal growth rate enjoyed by the nepheline syenite industry during the 1950's and early 60's has moderated as markets formally supplied by feldspar approached saturation. The glass industry continues to prosper, however, and with the expansion of other uses, a growth rate of 7 per cent per year is anticipated for the next 5 years with possibly an increase in 1972 of 10 per cent should indications of renewed economic vigour prove valid.

Prices and tariffs

Nepheline syenite prices vary from low-purity, crushed rock in bulk, at approximately \$5 a ton, to over \$24 a ton for finely ground high-purity products suitable for whitewares and filler applications. The average price of nepheline syenite used in the glass industry is in the order of \$12 a ton fob plant.

The largest export market is the United States where entry is duty free.

FELDSPAR

Feldspar is the name of a group of minerals that are aluminum silicates of potassium, sodium and calcium. Feldspars are of value to the ceramic industry as a source of alumina, potash and soda. Manufacturers of cleaning compounds use crushed feldspar for its moderately abrasive properties. High-calcium feldspars such as labradorite and feldspar-rich rocks like anorthosite find limited use as building stones and for other decorative purposes. Dental spar is a pure white feldspar free of iron and mica which is used in the manufacture of artificial teeth.

Feldspars occur in many rock types but commercially viable deposits are mostly restricted to coarse-grained granite pegmatites. The feldspar from these pegmatites is generally hand-cobbed to remove quartz and other unwanted associated minerals. The feldspar is then ground to the desired size. Nearly all feldspar produced in Canada has come from pegmatites in the Precambrian rocks of southern Ontario and southwestern Quebec.

Feldspar has been a long-standing source of alumina and alkalis in glass making and an important constituent in ceramic products. Alternative raw materials such as nepheline syenite have made significant inroads into feldspar's markets so that domestic consumption in the manufacture of glass, pottery and enamel has remained at about the same level for the past decade. Feldspar produced in Canada is consumed in the ceramic industry in southern Ontario and northwestern New York State. The trend toward standardization of methods in glass manufacture demanding uniformity of quality has favoured the use of nepheline syenite in a wide range of products formerly utilizing feldspar.

Table 3. Canada, feldspar production, 1970-71, consumption 1969-70

	1970	1971^p
Production[1]	10,656 st	10,000 st
	$290,541	$302,000
	1969	1970
Consumption[2] (available data)	(short tons)	
Whiteware	6,095	6,133
Porcelain enamel	417	358
Soaps and cleaning compounds	672^r	700^e
Other[3]	451	485
Total	7,635^r	7,676

Source: Statistics Canada.
[1]Producers' shipments; [2]Breakdown by Mineral Resources Branch; [3]Includes artificial abrasives, electrical apparatus, glass, paper and other minor uses.
^{p}Preliminary; ^{e}Estimated.

Table 4. Canada, feldspar production and trade, 1962-71
(short tons)

	Production[1]	Imports	Exports	Consumption
1962	9,994	1,901	3,698	6,818
1963	8,608	2,600	3,282	6,009
1964	9,149	..	3,386	7,493
1965	10,904	..	3,746	8,338
1966	10,924	..	3,419	8,528
1967	10,394	..	..	8,571
1968	10,620	..	..	7,343
1969	12,385	..	..	7,635^r
1970	10,656	..	..	7,676
1971^p	10,000	..	..	..

Source: Statistics Canada.
[1]Producers' shipments.
^{p}Preliminary; .. Not available; ^{r}Revised.

Table 5. World production of feldspar, 1970-71

	1970	1971^e
	(short tons)	
United States	725,760	712,320
West Germany	407,680	392,000
France	207,200	207,200
Italy	194,880	196,000
Norway	143,360	145,600
Japan	70,560	72,800
Sweden	34,720	33,600
Other countries	789,600	812,000
Total	2,573,760	2,571,520

Source: U.S. Bureau of Mines Commodity Data Summaries, January 1972.
^{e}Estimate.

Canadian production and developments

International Minerals & Chemical Corporation (Canada) Limited, the only Canadian producer of feldspar is closing down operations at its mine and mill at Buckingham, Quebec in mid-1972.

As a result of substitution by nepheline syenite, output of feldspar has declined steadily from 55,000 tons in 1947 to 10,000 tons in 1961, a level that persisted throughout the 1960's and in 1970 and 1971.

Several local producers of high value dental spar deliver small tonnages of this high-quality feldspar to IMC's mill at Buckingham.

Centex, a joint university-industry-government body in Manitoba, is investigating byproduct recovery of, and possible markets for, feldspar and other minerals from mining waste in the province. Tantalum Mining Corporation of Canada Limited mines tantalum from a pegmatite containing abundant feldspar at Bernic Lake, Manitoba and, should the study demonstrate that such an operation would be viable, this company could produce feldspar in the near future.

Markets

Canadian feldspar is now consumed almost entirely in the ceramics industry. 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 material costs are low in the ceramic industry in relation to total manufacturing costs and manufacturers 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 its 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". Potash feldspar utilized for ceramics are usually required to contain not less than 8 per cent K_2O and preferably over 10 per cent K_2O. The soda (Na_2O) content should be as low as possible, ideally zero, and the iron (Fe_2O_3) content under 0.1 per cent. Feldspar is important as a flux in the firing of whiteware bodies and glazes and is used principally in Canada in the manufacture of electric porcelain and vitreous sanitary ware. It must be minus 325 mesh and have a very low quartz and iron content—Fe_2O_3 should not exceed 0.1 per cent. For cleaning compounds, feldspar should be white and free of quartz. In the United States, in recent years, there has been a marked increase in the consumption of a naturally occurring feldspar-silica mixture for glass manufacture. Normally the mixture contains from 30 to 50 per cent feldspar.

Prices

United States feldspar prices in U.S. currency as quoted in Engineering and Mining Journal of December 1971

(per short ton, fob mine or mill, carload lots, depending on grade)

	($)
North Carolina	
40 mesh, flotation	14-20
20 mesh, flotation	12
200 mesh, flotation	21.50-26
Georgia	
200 mesh	24.50
325 mesh	25.50
40 mesh, granular	20
Connecticut	
200 mesh	22.50
325 mesh	23.50
20 mesh, granular	15.50

Tariffs

Canada

Item No.		British Preferential	Most Favoured Nation	General
29600-1	Feldspar, crude	free	free	free
29625-1	Feldspar, ground but not further manufactured	free	7½%	30%

United States

Item No.		On and After Jan. 1, 1970	On and After Jan. 1, 1971	On and After Jan. 1, 1972
522.31	Feldspar, crude	5¢ per ton	2¢ per ton	free
522.41	Feldspar, crushed, ground or pulverized	5%	4%	3.5%

Sources: The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa. Tariff Schedules of the United States Annotated (1971) TC Publication 344.

Nickel

C.J. CAJKA

1971 proved to be a difficult year for world nickel producers. The major nickel shortage, which began in 1966, came to an end in late 1970. By early 1971, the metal was in oversupply and this condition prevailed throughout the year, although the low point in the nickel market appeared to have been reached by year-end. Part of the problem lay in supply which was significantly increased in 1970-71; 1971 culminated a period of major production expansion in Canada. The other main influence was in demand, which remained sluggish throughout 1971 because of the decline in economic activity in the industrialized nations of the noncommunist world. With nickel inventories accumulating to abnormally high levels, producers announced they would reduce production and delay completion of new and expansion projects. Producers' prices remained steady throughout the year.

Canada maintained its position as the leader in nickel production, accounting for about 41 per cent of total world production. New Caledonia, with an estimated 18 per cent of production, and the U.S.S.R., with about 17 per cent, were the two next largest producers.

Canadian mine production of nickel in 1971 declined to 293,947 tons valued at $798,162,000 from 305,881 tons valued at $830,166,823 in 1970. Consumption of nickel in the noncommunist world was 412,500 tons. The comparable usage in 1970 was 487,500 tons.

Canadian operations and developments

Eight companies mined nickel ores in four provinces during 1971. 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 these same provinces. In addition to Ontario and Manitoba, a small amount of mine production was obtained from Quebec and British Columbia. Inco, Falconbridge and Sherritt Gordon Mines, Limited each have integrated mine-concentrator-smelter and refinery complexes where they process ore to the metal stage.

Seven new nickel and nickel-copper mines, three concentrators, and a nickel-iron refinery commenced operation in 1971. However, because of weak nickel demand and accumulating inventories, two mines and one concentrator were temporarily closed and production was reduced at several other mines by the end of 1971.

The International Nickel Company of Canada, Limited is the world's largest producer of nickel. Deliveries in 1971 of 171,225 tons accounted for 42 per cent of consumption in the noncommunist world. The company operated fourteen mines, five concentrators and two smelters in the Sudbury district and a nickel refinery at Port Colborne, Ontario. In Manitoba, Inco produced from four mines, one concentrator, one smelter and a nickel refinery at Thompson. Three mines in the Sudbury area (Coleman, Copper Cliff South, and Little Stobie) and two mines near Thompson (Pipe and Soab) were placed in production during 1971. The new Clarabelle concentrator, near Sudbury, was operational by year-end with a daily ore capacity of 35,000 tons. At Copper Cliff, Inco is constructing a new nickel refinery, which will utilize the company's pressure carbonyl process. The new plant, with an annual capacity of 50,000 tons

(text continued on page 7)

Table 1. Canada, nickel production, trade and consumption, 1970-71

	1970		1971[p]	
	(short tons)	($)	(short tons)	($)
Production[1]				
All forms				
Ontario	224,255	608,428,298	217,594	588,821,000
Manitoba	79,121	214,823,337	74,151	203,326,000
British Columbia	1,704	4,703,320	1,404	3,862,000
Quebec	801	2,211,868	798	2,153,000
Total	305,881	830,166,823	293,947	798,162,000
Exports				
Nickel in ores, concentrates, matte and speiss[2]				
Britain	40,092	108,339,000	51,183	138,196,000
Norway	46,450	114,678,000	50,810	127,123,000
Japan	9,954	23,675,000	10,090	24,177,000
Australia	–	–	20	45,000
Other countries	163	359,000	1	2,000
Total	96,659	247,051,000	112,104	289,543,000
Nickel in oxide sinter				
United States	27,335	64,958,000	28,451	66,865,000
Britain	10,269	25,793,000	9,062	21,424,000
Belgium and Luxembourg	4,975	12,624,000	4,067	10,461,000
Australia	957	2,495,000	879	2,293,000
Mexico	83	225,000	95	246,000
Other countries	276	675,000	94	199,000
Total	43,895	106,770,000	42,648	101,488,000
Nickel and nickel alloy scrap				
Italy	20	102,000	510	1,690,000
United States	2,268	3,433,000	926	1,062,000
Britain	411	2,200,000	226	562,000
France	70	133,000	97	277,000
Japan	305	1,194,000	88	226,000
Other countries	1,242	7,583,000	211	510,000
Total	4,316	14,645,000	2,058	4,327,000
Nickel anodes, cathodes, ingots, rods				
United States	103,385	255,040,000	85,437	207,675,000
Britain	26,376	70,230,000	29,251	71,124,000
Italy	1,474	4,285,000	1,923	6,187,000
Japan	2,225	7,992,000	2,006	5,477,000
Australia	1,886	5,755,000	1,712	4,715,000
India	1,934	7,499,000	846	2,645,000
Mexico	591	1,743,000	877	2,402,000
France	1,364	3,885,000	751	2,224,000
Brazil	536	1,857,000	574	1,674,000
West Germany	3,007	20,417,000	357	1,238,000
Sweden	523	2,919,000	296	790,000
China (Republic)	2,027	12,853,000	276	743,000
Chile	88	300,000	238	632,000
Other countries	7,787	23,206,000	817	2,571,000
Total	153,203	417,981,000	125,361	310,097,000

Table 1 (cont'd)

	1970		1971[p]	
	(short tons)	($)	(short tons)	($)
Nickel and nickel alloy fabricated material, nes				
United States	1,757	7,349,000	1,287	4,148,000
Hungary	16	70,000	384	1,628,000
Brazil	451	1,764,000	310	1,290,000
Netherlands	531	2,330,000	222	933,000
Britain	84	542,000	54	205,000
West Germany	115	909,000	68	191,000
Mexico	39	148,000	47	138,000
Other countries	657	3,122,000	151	362,000
Total	3,650	16,234,000	2,523	8,895,000
Imports				
Nickel in ores, concentrates and scrap				
Australia	11,913	29,495,000	9,134	17,471,000
United States	8,635	17,138,000	4,238	5,035,000
Britain	1,823	1,338,000	5,225	3,734,000
French Oceania	4,293	2,545,000	3,053	1,273,000
Other countries	3,015	87,000	89	78,000
Total	29,679	50,603,000	21,739	27,591,000
Nickel anodes, cathodes, ingots, rods				
Norway	11,787	32,402,000	13,324	37,079,000
Britain	–	–	659	1,827,000
Other countries	39	150,000	83	237,000
Total	11,826	32,552,000	14,066	39,143,000
Nickel alloy ingots, blocks, rods and wire bars				
United States	463	1,815,000	386	1,503,000
West Germany	–	–	26	111,000
Britain	9	45,000	6	22,000
Total	472	1,860,000	418	1,636,000
Nickel and alloy plates, sheet strip and flat products				
United States	1,246	4,865,000	1,260	4,595,000
West Germany	30	67,000	26	69,000
Other countries	10	52,000	15	78,000
Total	1,286	4,984,000	1,301	4,742,000
Nickel and nickel alloy pipe and tubing				
United States	345	1,460,000	401	3,546,000
West Germany	188	1,155,000	92	819,000
Other countries	1	9,000	...	2,000
Total	534	2,624,000	493	4,367,000
Nickel and alloy fabricated material, nes				
United States	276	1,782,000	262	1,350,000
Britain	47	249,000	55	315,000
West Germany	5	28,000	13	74,000
Other countries	2	12,000	7	31,000
Total	330	2,071,000	337	1,770,000
Consumption[3]	11,794		..	

Source: Statistics Canada.
[1]Refined nickel and nickel in oxides and salts produced plus recoverable nickel in matte and concentrates exported. [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; nes Not elsewhere specified; . . . Less than 1,000 lb.

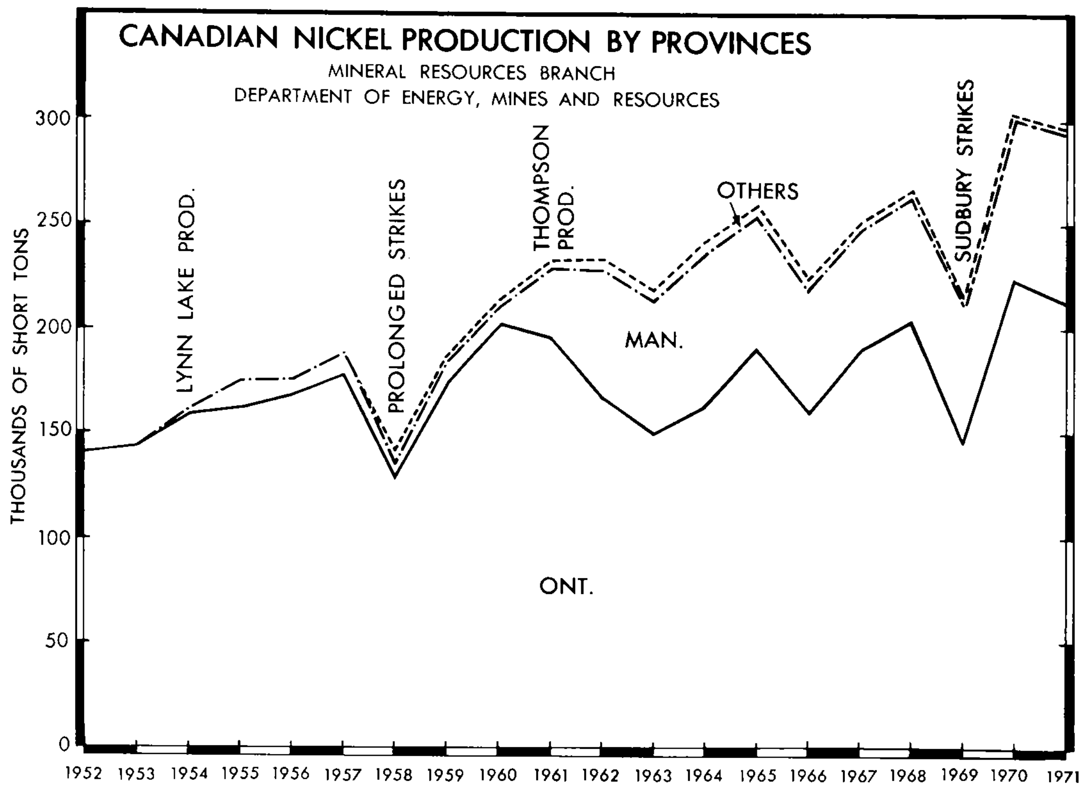


Table 2. Nickel, production, trade and consumption, 1962-71

	Production[1]	Exports In Matte, etc.	Exports In Oxide Sinter	Exports Refined Metal	Exports Total	Imports[2]	Consumption[3]
	(short tons)						
1962	232,242	77,410	11,120	121,712	210,242	7,494	5,322
1963	217,030	83,392	15,208	109,156	207,756	10,973	5,866
1964	228,496	74,766	35,800	128,330	238,896	10,444	6,899
1965	259,182	82,327	40,956	135,197	258,480	12,172	8,924
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
1971p	293,947	112,104	42,648	125,361	280,113	14,066	. .

Source: Statistics Canada.
[1]Refined metal and nickel in oxide and salts produced, plus recoverable nickel in matte and concentrates exported. [2]1962 to 1963 incl., nickel, semifabricated, comprising nickel and nickel alloys in ingot blocks, bars, rods, strip, sheet, etc.; 1964 and subsequent years, 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.
pPreliminary; . . Not available.

Table 3. Principal Canadian nickel mines, 1971 and [1970]

Company and Location	Mill or Mine Capacity[1]	Grade of Ore Nickel	Grade of Ore Copper	Ore Produced	Contained Nickel Produced	Remarks
	(tons ore/day)	(%)	(%)	(tons)	(tons)	
Quebec						
Renzy Mines Limited, Hainault Township	1,000 [1,000]	0.43 [0.46]	0.55 [0.51]	314,630 [324,015]	830 [957]	Smelter contract to be cancelled April 4, 1972.
Ontario						
Consolidated Canadian Faraday Limited, Werner Lake Division, Gordon Lake	1,100 [1,100]	0.83 [..]	0.35 [..]	99,731 [105,504]	638 [627]	Cut and fill mining phased out, replaced by blasthole stopes. Mills ore from Dumbarton mine.
Falconbridge Nickel Mines Limited, East, Falconbridge, Fecunis Lake, Hardy-Boundary, Longvack South, North, Onaping, and Strathcona mines, Falconbridge	3,000 (Falconbridge) 7,100 (Strathcona) 2,500 (Fecunis Lake) 1,500 (Hardy)	.. [..]	.. [..]	4,703,000 [4,631,000]	42,932[2] [42,071][2]	Construction deferred on Lockerby No. 2 shaft and surface plants, and on Fraser, Lindsley and Onex shafts. Lockerby No. 1 shaft completed in 1971.
The International Nickel Company of Canada, Limited, Clarabelle, Coleman, Copper Cliff North, Copper Cliff South, Crean Hill, Creighton, Frood-Stobie, Garson, Kirkwood, Levack, Little Stobie, Maclennan, Murray and Totten mines, Copper Cliff	35,000 (Clarabelle) (Copper Cliff, flotation only) 11,400 (Creighton) 24,000 (Frood-Stobie) 6,200 (Levack)	.. [..]	.. [..]	21,847,700 [22,996,100]	171,225[3] [259,435][3]	New Clarabelle mill replaced obsolete crushing and grinding equipment at Copper Cliff plant. Production suspended at Creighton mill. Production suspended at Murray, reduced at Creighton mine and Clarabelle open pit.
Texmont Mines Limited, Timmins	600 [–]	– [–]	.. [..]	74,240 [–]	401 [–]	Production began July, 1971. Concentrates are stockpiled.
Manitoba						
Dumbarton Mines Limited, Bird River	800 [700]	0.86 [..]	0.32 [..]	299,480 [252,552]	2,075 [1,170]	Ore trucked to Consolidated Canadian Faraday mill.

Table 3 (cont'd)

Company and Location	Mill or Mine Capacity[1]	Grade of Ore: Nickel	Grade of Ore: Copper	Ore Produced	Contained Nickel Produced	Remarks
	(tons ore/day)	(%)	(%)	(tons)	(tons)	
Falconbridge Nickel Mines Limited, Manibridge mine, Wabowden	1,000 [–]	. . [–]	. . [–]	. . [–]	42,932[2] [42,070][2]	Mine and mill placed in production in 1971.
The International Nickel Company of Canada, Limited, Birchtree, Pipe, Soab, and Thompson mines, Thompson	18,400 [12,000]	. . [. .]	. . [. .]	4,776,678 [3,861,700]	171,225[3] [259,435][3]	Production from Pipe and Soab began in 1971. Operations at Soab suspended Sept., 1971.
Sherritt Gordon Mines, Limited, Lynn Lake	3,500 [3,500]	0.66 [0.77]	0.41 [0.51]	1,158,000 [1,090,000]	5,825 [6,438]	Ore reserves recalculated, decreasing previous reserves by 2.6 million tons. Farley mine main decline completed to 3,700-foot level.
British Columbia						
Giant Mascot Mines Limited, Hope	1,750 [1,500]	0.77 [0.84]	0.39 [0.43]	260,241 [211,460]	1,625 [1,435]	Surface buildings rebuilt following fire in 1970. Production resumed May 1971. Ore reserves increased, largely in Chinaman zone but also in Climax, 4600, 2200, 1600 areas.

[1]Mill capacity in tons of ore a day. [2]Total nickel deliveries. [3]Ontario and Manitoba nickel deliveries.
. . Not available; – Nil.

Table 4. Prospective[1] Canadian nickel mines

Company and Location	Mill Capacity (tons of ore/day) and Ore Grade (%)	Year Production Expected	Destination of Nickel Concentrates	Remarks
Ontario				
Falconbridge Nickel Mines Limited, Falconbridge,				
Fraser mine	. .	. .	Own smelter	Deferred
Lindsley mine	–	. .	Own smelter	Deferred
Lockerby mine	–	. .	Own smelter	Development and construction curtailed.
Onex mine	. . Ni(. .) Cu(. .)	. .	Own smelter	Deferred
The International Nickel Company of Canada, Limited, Copper Cliff, Levack West mine	– Ni(. .) Cu(. .)	1975	Own smelter	2,500 tons/day to company's mills.
The International Nickel Company of Canada, Limited, Shebandowan	2,500 Ni(. .) Cu(. .)	1972	Own smelter	
Noranda Mines Limited, Timmins, Langmuir mine	700 Ni (1.87) Cu(. .)	1973	. .	Joint project with Inco Surface plants to be completed in 1972.
Yukon Territory				
Hudson-Yukon Mining Co., Limited, Kluane Lake, Wellgreen mine	600 Ni (2.04) Cu (1.42)	1972	Japan	Unexpected problems with orebody have resulted in decision to close mine in 1973.

[1]Only mines with announced production plans.
. . Not available; – Nil.

of nickel pellets and 12,500 tons of nickel powder, is scheduled for production in 1973. Also in Ontario, Inco is preparing its Shebandowan mine and concentrator for production in 1972 at 2,500 tons of ore a day.

In an attempt to bring nickel production in line with demand, International Nickel announced that it would reduce output, 22 per cent by January 1972 and an additional 10 per cent effective April 1972. Included in the curtailments were suspension of production at the Murray and Crean Hill mines, Creighton concentrator and Coniston smelter, all in the Sudbury area, the Soab mine at Thompson, as well as reductions at other operations. Inco has also scheduled a three-week shutdown of all plants in Ontario for the 1972 summer vacation period.

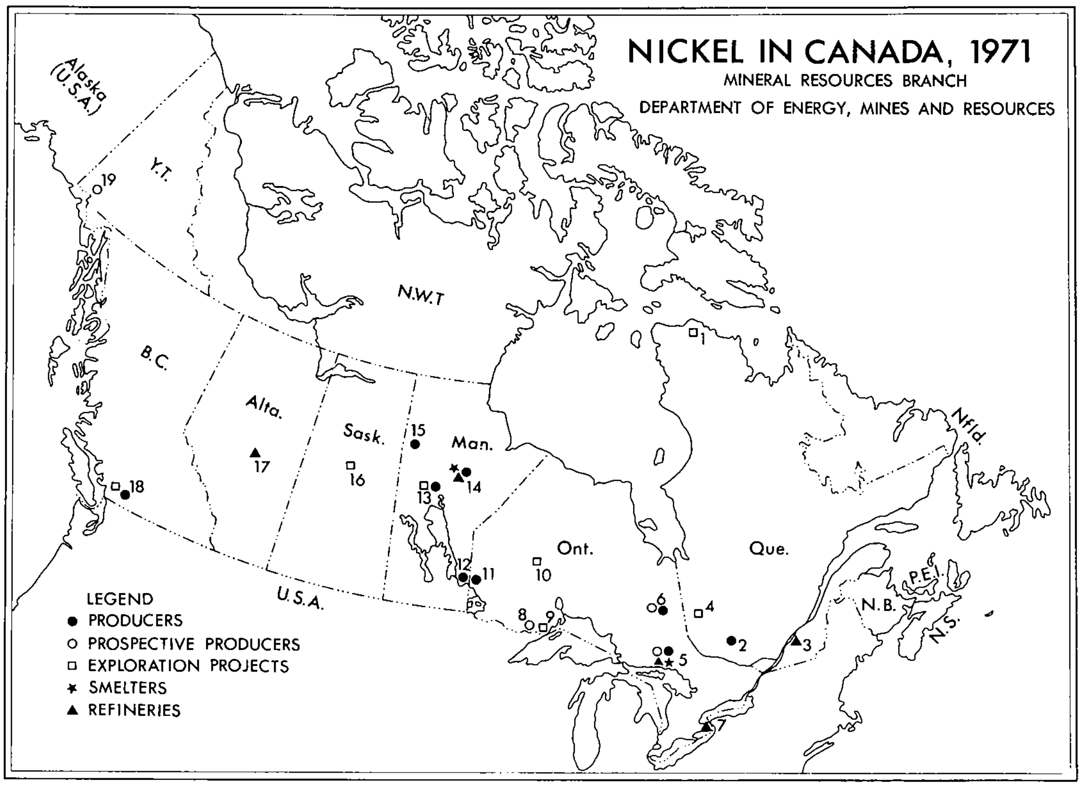
Falconbridge Nickel Mines Limited operated eight mines, four concentrators and one smelter in the Sudbury area of Ontario. Late in the year, the company announced that its nickel-iron refinery at Falconbridge was in operation. This plant, with a designed annual capacity of 500,000 tons of product, utilizes pyrrhotite concentrates to produce nickel-iron pellets containing more than 95 per cent iron and 1.5 per cent nickel. The Manibridge project, a mine and concentrator operation located near Wabowden in Manitoba, was placed in production by Falconbridge during 1971 to process 1,000 tons of ore a day. Manibridge concentrates are shipped to the company's smelter in Ontario. Falconbridge Nickel Mines Limited was developing four new mines and one concentrator for production but, during 1971, announced that these projects would be deferred. As part of its plan to reduce the effect of escalating costs and to restrain nickel production, the company is closing the Longvack South mine and the Hardy concentrator. Falconbridge has announced plans to construct a refinery at Bécancour, Quebec. All nickel-copper matte from the Falconbridge smelter is currently shipped to the company's refinery at Kristiansand, Norway. The new refinery, which will use a matte acid-leach and fluidized-bed process developed by Falconbridge, is designed to produce 15,000 tons of nickel, 11,000 tons of copper, 250 tons of cobalt and 7,000 tons of sulphur a year. Falconbridge will close all its Ontario plants for two weeks during the 1972 summer vacation period.

The third-largest Canadian nickel producer is Sherritt Gordon Mines, Limited. Sherritt Gordon continued to operate its Lynn Lake, Manitoba, nickel mine and concentrator but ore production and grade have been decreasing over the past few years. Lynn Lake nickel concentrates are shipped to the company's hydrometallurgical refinery at Fort Saskatchewan, Alberta. During 1971 Sherritt Gordon imported matte and concentrates, on both a purchase and toll refining basis, to keep its refinery operating at capacity. Production in 1971 from its own ore amounted to 5,469 tons of refined nickel, and a further 11,087 tons came from Australia and New Caledonia.

Renzy Mines Limited had a normal year of production from its nickel-copper property in Hainault Township, Quebec. The company ships concentrates to Falconbridge for smelting. Renzy has been advised that its smelter contract with Falconbridge will be terminated on April 4, 1972. For lack of alternative markets, it will be necessary to close the Renzy operation.

In 1971 a new producer, Texmont Mines Limited, began mining and concentrating nickel ore at a rate of 500 tons of ore a day from its property near Timmins, Ontario. All concentrates from the project have been stockpiled but the owners hope to process these in a small hydrometallurgical plant they have constructed at Timmins. The plant is designed to produce nickel sulphate, electrolytic nickel and cobalt concentrates.

Consolidated Canadian Faraday Limited at its Gordon Lake, Ontario mine and concentrator and Dumbarton Mines Limited at Bird River, Manitoba experienced routine operations during 1971. Dumbarton trucks its ore to Faraday's concentrator and, from there, ships concentrates to Falconbridge for smelting. Consolidated Canadian Faraday ships its concentrates to an International Nickel smelter.



Producers

(numbers refer to numbers on map)

2. Renzy Mines Limited (Hainault Township)
5. Falconbridge Nickel Mines Limited (East, Falconbridge, Fecunis, Hardy-Boundary, Longvack South, North, Onaping, and Strathcona mines)
   The International Nickel Company of Canada, Limited (Clarabelle, Coleman, Copper Cliff North, Copper Cliff South, Crean Hill, Creighton, Frood-Stobie, Garson, Kirkwood, Levack, Little Stobie, MacLennan, Murray, and Totten mines)
6. Texmont Mines Limited (Timmins)
11. Consolidated Canadian Faraday Limited (Gordon Lake)
12. Dumbarton Mines Limited (Bird River)
13. Falconbridge Nickel Mines Limited (Manibridge mine)
14. The International Nickel Company of Canada, Limited (Birchtree, Pipe, Soab, and Thompson mines)
15. Sherritt Gordon Mines, Limited (Lynn Lake)
18. Giant Moscot Mines Limited (Hope)

Prospective Producers

5. Falconbridge Nickel Mines Limited (Lockerby, Lindsley, Fraser, and Onex mines)
   The International Nickel Company of Canada, Limited (Levack West mine)
6. Noranda Mines Limited (Langmuir mine)
8. The International Nickel Company of Canada, Limited (Shebandowan)
19. Hudson-Yukon Mining Co., Limited (Wellgreen mine)

Nickel Exploration Projects

1. New Quebec Raglan Mines Limited (Ungava)
   Expo Ungava Mines Limited (Ungava)
4. Dumont Nickel Corporation (Launay Township)
5. The International Nickel Company of Canada, Limited (Cryderman, North Range, Victoria and Whistle mines)
9. Great Lakes Nickel Limited (Pardee Township)
10. Union Minière Explorations and Mining Corporations Limited (Pickle Crow)
13. Bowden Lake Nickel Mines Limited (Bowden Lake and Bucko Lake mines)
16. National Nickel Ltd. and Cadillac Explorations Limited (Nemeiben Lake)

Smelters

5. Falconbridge Nickel Mines Limited (Falconbridge)
   The International Nickel Company of Canada, Limited (Coniston)
   The International Nickel Company of Canada, Limited (Copper Cliff)
14. The International Nickel Company of Canada, Limited (Thompson)

Refineries

3. Falconbridge Nickel Mines Limited (Bécancour): Under construction
5. Falconbridge Nickel Mines Limited (Falconbridge): Nickel-iron refinery
   The International Nickel Company of Canada, Limited (Copper Cliff): Pressure Carbonyl nickel refinery scheduled for completion in 1973.
7. The International Nickel Company of Canada, Limited (Port Colborne)
14. The International Nickel Company of Canada, Limited (Thompson)
17. Sherritt Gordon Mines, Limited (Fort Saskatchewan.

In British Columbia, Giant Mascot Mines Limited returned to full production during 1971. A fire had destroyed nearly all surface buildings at the mine site in the summer of 1970 and production was curtailed until new facilities were constructed. The company ships bulk nickel-copper concentrates to Japan and recently, because of the present slowdown in Japanese metal markets, arranged for additional process accommodation at the Sherritt Gordon refinery.

Hudson-Yukon Mining Co., Limited is preparing the Wellgreen mine and concentrator, near Kluane Lake in the Yukon Territory, for production in mid-1972. Underground development work carried out in 1971 unexpectedly revealed that the mineralization is irregular and discontinuous, and the mine is subject to poor ground conditions. Although Hudson-Yukon has made allowances for these discouraging developments by changing the mining method, the company recently announced that the mine, formerly reported to have a life of five years, will be closed early in 1973.

Table 3 provides information on all producing nickel mines in Canada and Table 4 lists those mines which have announced plans for production. Table 5 lists nickel properties which are at the exploration stage of development.

One major nickel discovery was reported in 1971. Union Minière Société Anonyme announced that its Canadian exploration subsidiary Union Minière Explorations and Mining Corporation Limited (Umex), has investigated a nickel-copper deposit near Pickle Crow in northwestern Ontario. The orebody, named the Thierry deposit, contains 10 million tons of ore, averaging 1.6 per cent copper and 0.2 per cent nickel. The company is proceeding with plans to sink an exploration shaft and carry out underground development. In Ungava, Quebec, Falconbridge and New Quebec Raglan Mines Limited proceeded with construction of roads on their nickel-copper property. Ore reserves remain unchanged at 16,050,000 tons of 2.58 per cent nickel and 0.71 per cent copper. Feasibility and engineering studies are being continued. Falconbridge continued to work on the Bucko Lake property of Bowden Lake Nickel Mines Limited

Table 5. Nickel exploration project

Company and Location	Indicated Ore (tons)	Grade of Ore (%)	Remarks
Quebec			
Dumont Nickel Corporation, Launay Township	480,000,000	Ni(0.327)	Surface diamond drilling continued and feasibility study undertaken.
Expo Ungava Mines Limited, Ungava	18,500,000	Ni(0.47) Cu(0.52)	
New Quebec Raglan Mines Limited, Ungava	16,050,000	Ni(2.58) Cu(0.71)	Road construction in 1971. Feasibility studies and engineering continuing.
Ontario			
Great Lakes Nickel Limited, Pardee Township	40,000,000	Ni(0.20) Cu(0.40)	Feasibility study completed. Arrangements for financing are in progress.
The International Nickel Company of Canada, Limited, Copper Cliff,			
Cryderman mine	..	Ni(. .)	
North Range mine	..	Cu(. .)	
Victoria mine	..		
Whistle mine	..		
Union Minière, Exploration and Mining Corporation Limited Pickel Crow, Thierry deposit	10,000,000	Ni(0.29) Cu(1.60)	Shaft sinking and underground exploration to be undertaken.
Manitoba			
Bowden Lake Nickel Mines Limited, Wabowden,			
Bowden Lake mine	80,000,000	Ni(0.60)	Shaft completed to 1,117 feet.
Bucko Lake mine	30,000,000	Ni(0.78)	Plan underground exploration program.
Saskatchewan			
National Nickel Ltd. and Cadillac Explorations Limited,	5,476,000	Ni(0.34) Cu(0.18)	Open pit reserves
Nemeiben Lake, La Ronge	1,754,500	Ni(0.38) Cu(0.70)	Underground reserves

in Manitoba. A shaft was completed to 1,117 feet and an underground exploration program is to be initiated. Giant Mascot Mines Limited participated with Giant Explorations Limited in exploring a property near Hope, British Columbia. The companies report finding an extensive area of mineralization which assays 0.22 per cent nickel. Some metallurgical testing has been completed.

World developments

World mine production of nickel decreased from 732,586 tons in 1970 to an estimated 713,000 tons in 1971. The decrease was partly caused by the voluntary reduction of mine production in Canada and also by a labour dispute which closed the operations of Société Le Nickel, in New Caledonia, for two months.

Increasing concern over the shortage of nickel during the past few years, higher nickel prices, and the heavy dependence on Canadian sources for supplies have contributed to growing activity in other countries to bring nickel deposits, largely of garnierite and lateritic types, into production. More recently, however, with respect to the softening nickel market, most hopeful producers have found it necessary to re-

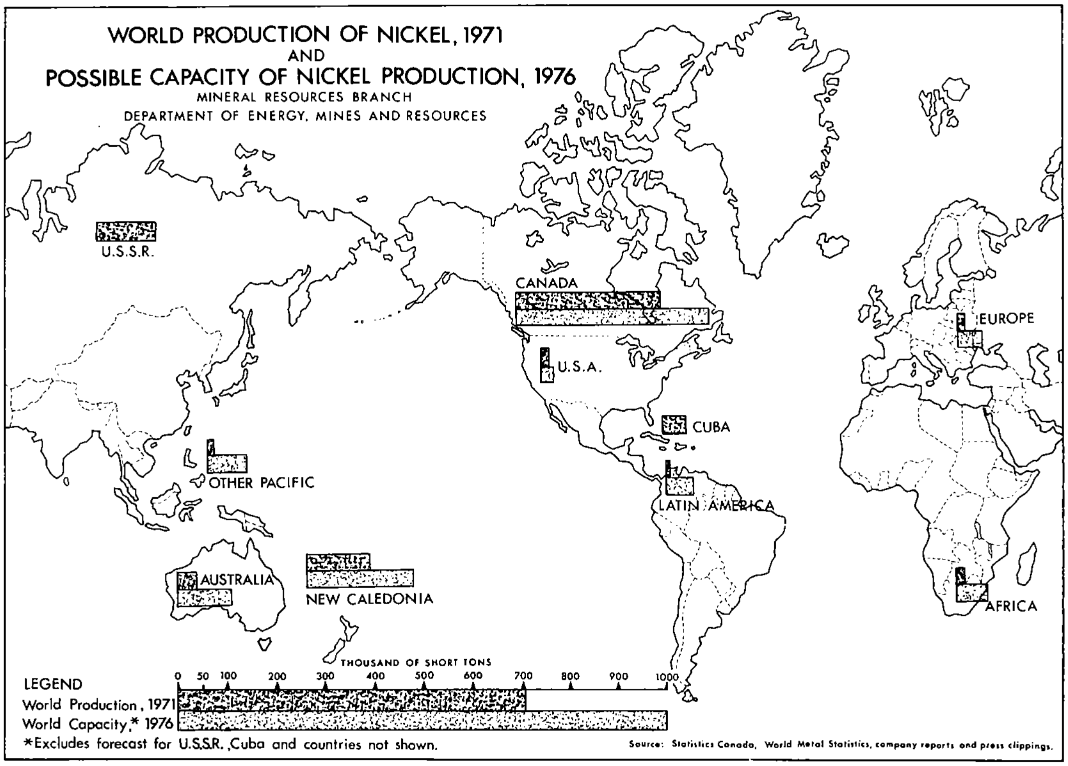


Table 6. World production[1] of nickel, 1970-71

	1970	1971[e]
Canada	305,881	294,000
New Caledonia	152,670	130,000
U.S.S.R.	121,254	121,200
Cuba	44,092	48,500
Australia	30,754	35,400
United States	15,543	16,700
Indonesia	11,905	13,600
Republic of South Africa	12,787	14,100
Greece	9,480	11,500
Finland	5,512	4,000
Rhodesia	12,125	12,800
Brazil	2,866	3,500
Poland	2,205	2,000
Others	5,512	5,700
Total	732,586	713,000

Sources: *World Metal Statistics,* June 1972. For Canada, Statistics Canada. U.S. Bureau of Mines Commodity Data Summaries, January 1972, for New Caledonia.
[1] Production all forms. [e]Estimated.

evaluate their projects and some have curtailed their plans while others have announced delays and deferments. The list of projects in Table 7 shows the more recent developments taking place in other countries. Four of these projects are especially noteworthy. Arrangements have been made for the sale of nickel and copper from the Selebi-Pikwe property in Botswana. The operators, Bamangwato Concessions Ltd., plan to produce nickel-copper matte which will be refined at Port Nickel, Louisiana, U.S.A. The mine-smelter complex, scheduled for operation in late 1973, is to have a designed capacity of 18,700 tons of nickel a year. Freeport Mineral Company and Metals Exploration N.L. have announced that they will place their Greenvale deposit, in Queensland, Australia, into production by the end of 1974. Most of the financing for this $265 million laterite project has been arranged, as well as sales contracts for nickel and cobalt to be produced at the plant. In the Dominican Republic, Falconbridge Nickel Mines Limited brought its new ferronickel plant on stream during 1971. This $195 million laterite project is designed to produce 31,500 tons of nickel a year. Marinduque Mining & Industrial Corporation has successfully completed financing for its $232.5 million laterite project located

Table 7. Prospective world nickel producers[1]

Company	Annual Capacity	Announced Date of Production	Destination of Concentrates	Remarks
	(tons of contained nickel)			
Australia				
Freeport Minerals Company and Metals Exploration N.L., Greenvale deposit, Queensland	27,000	1974	Own smelter	Smelter to be built at Townsville.
Freeport Minerals Company, Australian Consolidated Minerals, N.L., and Metals Exploration N.L., Mt. Keith, Western Australia	..	..	..	May begin production in 1975.
Poseidon N.L., Union Oil Company of California, Homestake Mining Company and The Hanna Mining Company, Windarra, Western Australia	30,000	..	..	Initial production expected to be much less. Mine production may begin in 1973.
Selection Trust Limited, Spargoville, Western Australia	6,000	1972	Kalgoorlie	Production from No. 2 location to begin in 1972; from No. 3, in 1973.
Botswana				
Bamangwato Concessions Ltd., Selebi-Pikwe	18,700	1973	Port Nickel, Louisiana, U.S.A.	
Colombia				
The Hanna Mining Company, Compania Niquel Chevron and Industrial Development Institute of Colombia, Cerro Matoso, Córdoba	18,750	1975-76	Own smelter	Re-evaluation in progress.
Dominican Republic				
Falconbridge Dominicana C. Por A.	31,500	1971	Own smelter	First shipment of ferronickel Dec. 1971.
Finland				
Outokumpu Oy, Vuonos mine	2,200	1972	Own smelter	Operates several nickel mines and a smelter in Finland
Greece				
Intercontinental Mining and Abrasives, Inc. and Southland Mining Company, Evia mine, Lake Ionina	9,000	1974	Own smelter	Proposal not yet approved by government.
Intercontinental Mining and Abrasives, Inc., Athens	6,000	1974	Own smelter	Smelter only. Ore to be supplied by other mining companies.

Table 7 (cont'd)

Company	Annual Capacity	Announced Date of Production	Destination of Concentrates	Remarks
	(tons of contained nickel)			
Guatemala				
Exploraciones y Explotaciones Mineral Izabal, S.A. (EXMIBAL), Lake Izabal	30,000	. .	Own refinery	To produce fire-refined nickel. Production possible 3 years after construction begins.
Indonesia				
P.T. International Nickel Indonesia, Malili, Sulawesi	25,000	. .	Own refinery	Plans to expand to 50,000 tons/yr. Financing incomplete. May begin production in mid-70's.
P.T. Pacific Nikkel Indonesia, Waigeo area, Irian Barat	25,000	. .	Own smelter	12,000 tons ore shipped to Sherritt Gordon Mines Limited for test treatment.
Sulawesi Nickel Development Cooperation Company (SUNIDECO), Pomalea, Sulawesi	13,200	. .	Own smelter	To produce ferronickel for export to Japan.
New Caledonia				
The International Nickel Company of Canada, Limited	11,000	. .	Own refinery	Plans to expand to 110,000 tons/yr. Could be in production in 1975.
New Caledonia Nickel Company, Doniambo	33,000	1972	Own smelter	Expansion of smelter capacity only.
The Patino Mining Corporation, Péchiney-Cie de Produits Chimiques et Electrométallurgiques and Ugine Kuhlmann, Poum	40,000	1974	Own smelter	Former SOMECA project.
Société Nationale des Pétroles d'Aquitaine and Freeport Minerals Company	25,000	. .	Own smelter	
Société Minière et Métallurgique de Penarroya, S.A. and American Metal Climax, Inc. (PENAMAX)	25,000	1975	Port Nickel, Louisiana, U.S.A.	
Republic of the Philippines				
Marinduque Mining & Industrial Corporation Nonoc Island	37,500	1973	Own refinery	Constructing Sherritt Gordon-type refinery.
Infanta Mineral and Industrial Corporation, Palawan Island	8,000	1972	Japan	

Table 7 (cont'd)

Company	Annual Capacity	Announced Date of Production	Destination of Concentrates	Remarks
	(tons of contained nickel)			
Rhodesia				
Johannesburg Consolidated Investment Company, Shangani mine	4,500	1974-75	Own smelter	Plans to expand to 7,500 tons nickel a year.
Yugoslavia				
Government company	13,000	. .	Own smelter	Will produce 48,500 tons of ferronickel. Could be in production in 1976.

Source: Annual reports and technical press.
[1]Companies which have announced probable production dates. . . No information.

on Nonoc Island in the Philippines. The complex is designed to produce 37,500 tons of nickel a year and is scheduled for completion in 1974. Marinduque will use a Sherritt Gordon process to refine its nickel.

Although several laterite projects have been curtailed or deferred, many companies are still proceeding with plans to develop a large production capacity over the next five years. Table 8 shows noncommunist world production capacity, based on recent company announcements, for each year up to 1976. If all of the planned projects are brought to production on their scheduled start-up dates, the industry will undoubtedly face a long period of nickel oversupply. For this reason, it is anticipated that several large nickel ventures will be deferred for a few years and annual capacity in 1976 for the noncommunist world will be held to about 825,000 tons of nickel. Even this figure could be excessive. The accompanying pie diagrams show the distribution of noncommunist world nickel mine capacity by country for 1971 and 1976.

Table 8. Noncommunist world mine nickel production capacity

	1972	1973	1974	1975	1976
	(thousands of short tons)				
Canada	322	347	380	395	395
New Caledonia	141	142	153	180	221
Latin America	28	35	35	35	55
Australia	37	46	53	74	107
Europe	23	26	43	51	51
Africa	27	38	57	65	68
Other Pacific	18	22	32	48	84
United States	17	18	18	19	19
Total	613	674	771	867	1,000

Source: Company reports and technical press.

Table 9. Noncommunist world nickel consumption by use, 1970-71

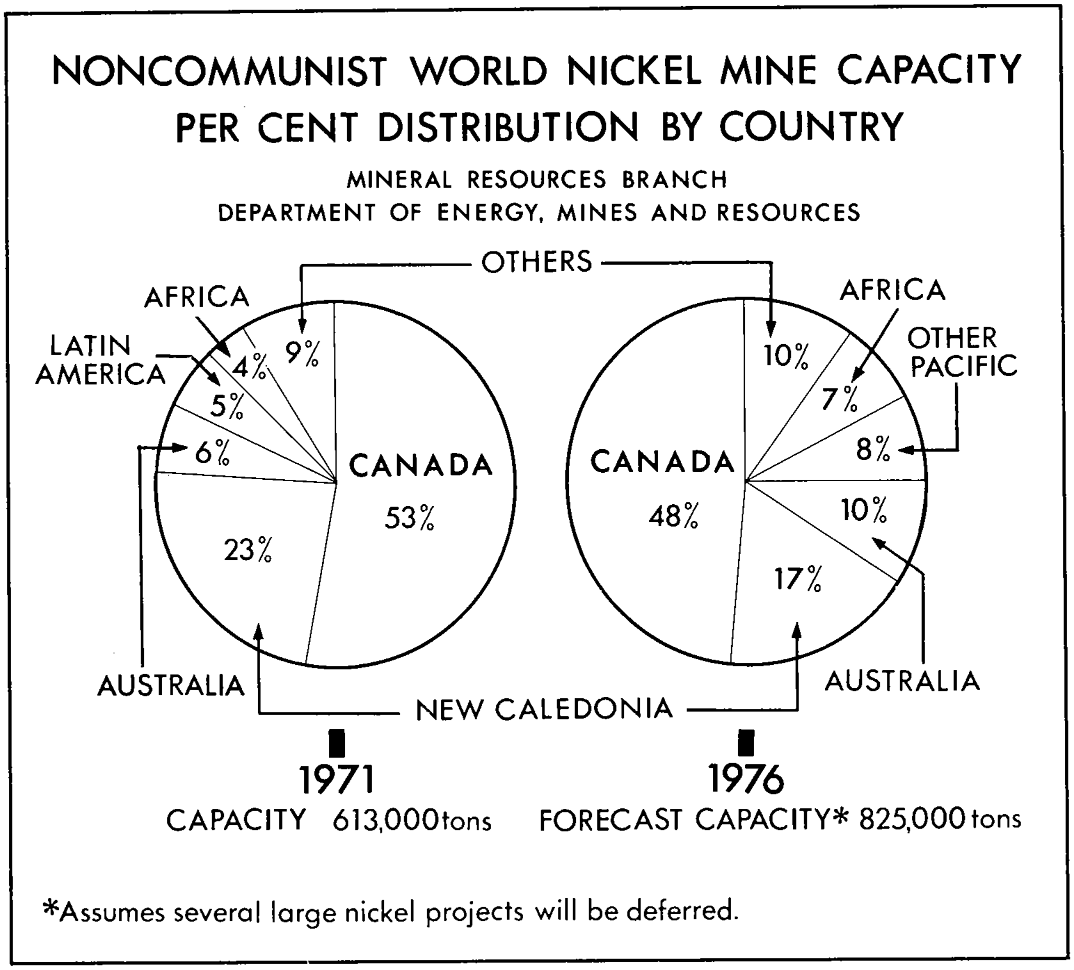
	1970	1971^{e}
	(millions of pounds)	
Stainless steels	402	338
High-nickel alloys	132	99
Nickel plating	129	131
Constructional alloy steels	106	82
Iron and steel castings	85	75
Copper and brass products	32	25
Other	89	75
Total	975	825

Source: The International Nickel Company of Canada, Limited.
^{e}Estimated.

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. Nickel plating, which cannot use nickel scrap, was the only category to register an increase in nickel usage in 1971. 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 gas turbine engines for surface applications, cryogenic containers, nuclear generating plants and pollution abatement equipment.

Outlook

The depressed nickel market, which dominated the industry during 1971, is expected to improve throughout 1972 and 1973 as world economies, particularly those of the United States, Europe and Japan, gain momentum. World demand for nickel should grow rapidly over the next three years, thereafter reverting to its long-term growth rate. Canadian production will be slow to reflect demand recovery because of a large inventory of unsold metal held by Canadian producers. Operations which have been suspended could remain in this state for one or two more years. Labour contracts with the major companies at Sudbury are subject to renegotiations during the summer of 1972 but, unless there is an unusually long work stoppage, a strike will not drastically change the nickel picture. Finally, with respect to oversupply, there is some concern for the many major laterite projects scheduled for production in the mid-seventies. With the exception of those which are in an advanced state of development, most will be delayed and are unlikely to achieve announced capacity production until the 1980's.

Prices

Producers' prices for Canadian nickel remained unchanged during 1971. Falconbridge International Limited, a wholly owned subsidiary of Falconbridge nickel Mines Limited, has announced that its new ferronickel product from the Dominican Republic operation will be sold on the basis of nickel content which is to be priced at 4 cents a pound lower than electrolytic nickel. In the United States, The Hanna Mining Company reduced the price of its ferronickel to $1.28 (U.S.) a pound of contained nickel. This action presumably was taken to make United States ferronickel more competitive with Inco's Sinter "90".

Free market, or merchant nickel, was sold during the latter half of 1971 at about 10 cents below producers' quotations and some sales were reported at prices as low as $1 a pound. Nickel sold at greatly discounted prices is believed to have originated from overstocked consumer inventories, small foreign nickel producers, and the U.S.S.R.

	Canada	United States
	Jan. 1–Dec. 31	Jan. 1–Dec. 31
	(cents a pound)	
Inco, electrolytic, fob Port Colborne, Ontario and Thompson, Manitoba	137.5	133.0
Falconbridge, electrolytic, fob Thorold, Ontario	137.5	133.0
Inco, Nickel Oxide Sinter "75"	131.0	127.0
Inco, Nickel Oxide Sinter "90"	132.0	128.0

	Jan. 1–20	Jan. 21–Dec. 31	Jan. 1–20	Jan. 21–Dec. 31
Sherritt Gordon, briquettes or powder, fob Niagara Falls, Ontario and Fort Saskatchewan, Alberta	128.0 (U.S.)	133.0	128.0	133.0

Tariffs

Canada Item No.		British Preferential	Most Favoured Nation	General
		(%)	(%)	(%)
35500–1	Nickel, and alloys containing 60 % or more nickel by weight, not otherwise provided for, viz: ingots, blocks and shot; shapes or section, 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
32900–1	Nickel ores	free	free	free
33506–1	Nickelous oxide	10	15	25
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
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
35800–1	Anodes of nickel	free	free	10

Tariffs (Cont'd)

Canada Item No.		British Preferential	Most Favoured Nation	General
		(%)	(%)	(%)
35515–1	Nickel, and alloys containing 60% by weight or more of nickel, in powder form	free	free	free
35520–1	Nickel or nickel alloys, namely: matte, sludges, spent catalysts and scrap, and concentrates other than ores	free	free	free
44643–1	Articles of iron, steel or nickel, or of which iron, steel or nickel are the component materials 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
37506–1	Ferronickel	free	5	5

United States Item No.				
601.36	Nickel ore	free		
603.60	Nickel matte	free		
620.03	Nickel, unwrought	free		
		On and After January 1		
		1970	1971	1972
			(¢ per lb)	
620.04	Nickel waste and scrap (duty suspended on or before June 30, 1973)	0.5	0.2	free
620.30	Nickel flakes	7	6	5
620.32	Nickel powders	free	free	free
620.50	Nickel electroplating anodes, wrought and cast, of nickel	7%	6%	5%

Sources: The Custom Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa. United States, Tariff Schedules of the United States Annotated (1972) TC Publication 452.

Petroleum

W.G. Lugg

The steadily expanding market for Canadian oil production spurred exploration for new reserves over a broad front in 1971 and the search was rewarded by the first significant oil and gas discovery off Canada's east coast on Sable Island and several additional discoveries in the Mackenzie Delta and Arctic island regions of northern Canada. The producing sector of the oil and gas industry again enjoyed a prosperous year, as output of crude oil and natural gas liquids rose to a new high of 1.58 million barrels a day (b/d). Revenue from the sale of oil and gas production exceeded $1.9 billion and expenditures by the industry reached $1.6 billion. The significant increase in revenue this year could be largely attributed to the 25 cents per barrel increase in the wellhead price of crude oil made late in 1970, whereas the jump in expenditures was partly due to the growing pace of costly northern and offshore exploration.

In world markets, a substantial increase in the price of crude oil was obtained from producing companies operating within the boundaries of member states of the Organization of Petroleum Exporting Countries (OPEC). In so doing, OPEC has likely established a trend that will influence the pricing structures of other oil-producing countries.

Continuing strong demand for Canadian crude oil and products in the United States mid-continent market accounted for an over-all 11.8 per cent rise in exports to 841,000 b/d to that country, although exports to the west coast of the United States declined in 1971. Value of exports of crude oil and products was approximately $874 million. Imports of crude oil and products amounted to 819,000 b/d in 1971, 56,500 b/d more than in 1970.

Pipeline construction increased substantially in 1971 and northern Canadian pipeline research projects accelerated their efforts preparatory to future construction of major pipeline systems which may be built to tap the potential reserves of Arctic areas. One of these research projects deals with oil transmission and two others with the problems of transporting natural gas in permafrost areas. Refinery capacity in Canada experienced a major upturn in 1971 as three new refineries came on stream and significant expansions to existing plants were completed.

Production

Net production of Canadian crude oil and natural gas liquids averaged 1.58 million b/d in 1971, an increase of 106,000 b/d or 7 per cent over 1970. Crude oil output alone amounted to 1.35 million b/d and natural gas liquids reached 236,000 b/d, comprised of 128,000 b/d of pentanes plus and condensate and 108,000 b/d of propane and butane. Alberta production increased by 9 per cent to 1,015,000 b/d and accounted for 75.5 per cent of total Canadian crude oil production. Of this amount, synthetic crude oil production from the Athabasca tar sands contributed over 42,000 b/d during 1971. Saskatchewan crude oil production declined by 3,000 b/d to 242,000 b/d in 1971, accounting for 17.8 per cent of the Canadian total. British Columbia's production remained static at 69,200 b/d and represented 5 per cent of total national production. Manitoba again accounted for 1.4 per cent and Ontario, the Northwest Territories and New Brunswick together, 0.3 per cent. All provinces except Alberta were producing crude oil near capacity.

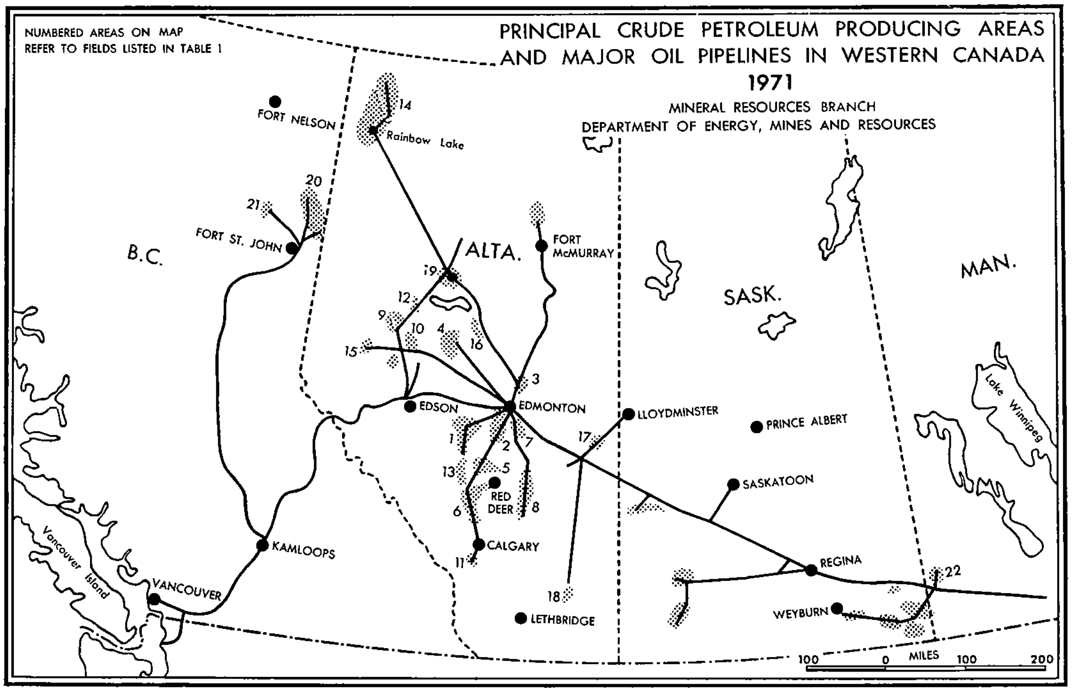


Table 1. Production of crude oil and condensate by province and field, 1970-71

(number in parenthesis gives location of field on the accompanying map)	1970		1971p	
	(barrels)	(bbl/day)	(barrels)	(bbl/day)
Alberta				
Pembina (1)	51,069,288	139,916	53,872,369	147,596
Swan Hills (4)	28,086,473	76,949	32,975,072	90,343
Rainbow (14)	22,593,474	61,900	24,185,186	66,261
Redwater (3)	21,159,217	57,970	23,077,286	63,225
Judy Creek	15,842,189	43,403	17,702,358	48,500
Swan Hills South (4)	12,555,119	34,398	14,334,794	39,273
Bonnie Glen (2)	13,447,994	36,844	14,328,615	39,256
Mitsue (16)	11,573,443	31,708	13,504,248	36,998
Golden Spike (2)	13,605,623	37,276	11,994,551	32,862
Wizard Lake (2)	10,072,801	27,597	11,547,117	31,636
Nipisi (19)	10,567,624	28,951	10,740,108	28,896
Fenn-Big Valley (8)	7,145,052	19,574	7,769,951	21,288
Leduc-Woodbend	6,075,965	16,646	6,228,327	17,064
Virginia Hills (4)	5,508,817	15,091	5,857,919	16,049
Carson Creek North (4)	4,774,374	13,080	5,242,678	14,364
Willisden Green (13)	4,403,943	12,064	5,093,679	13,955
Sturgeon Lake South	4,282,954	11,734	4,507,375	12,349
Kaybob (10)	3,986,541	10,921	4,410,848	12,085
Zama (14)	5,109,720	13,998	4,095,681	11,221
Acheson (2)	3,446,800	9,443	3,620,791	9,920
Westerose (2)	3,441,561	9,427	3,231,017	8,852

Table 1 (Continued)

(number in parenthesis gives location of field on the accompanying map)	1970 (barrels)	1970 (bbl/day)	1971p (barrels)	1971p (bbl/day)
Rainbow South (14)	2,997,645	8,211	3,172,882	8,693
Snipe Lake	2,357,110	6,458	2,827,630	7,747
Harmattan East (6)	2,191,158	6,002	2,672,928	7,323
Joffre (5)	2,481,367	6,797	2,588,423	7,092
Virgo (14)	3,924,825	10,751	2,574,232	7,053
Kaybob South (10)	1,664,318	4,559	2,521,979	6,910
Wainwright (17)	2,433,744	6,667	2,402,600	6,582
Innisfail (6)	2,021,131	5,537	2,383,100	6,529
Bantry (18)	2,510,715	6,878	2,376,645	6,511
Joarcam (7)	2,177,209	5,964	2,348,232	6,434
Clive	1,680,048	4,602	2,326,404	6,374
Medicine River (13)	2,103,116	5,760	2,090,663	5,728
Provost	1,416,272	3,880	1,967,032	5,389
Goose River	1,746,309	4,783	1,938,208	5,310
Harmattan-Elkton (6)	1,478,147	4,049	1,777,909	4,871
Gilby (5)	1,589,341	4,353	1,761,096	4,825
Bellshill Lake	1,353,158	3,707	1,735,739	4,755
Simonette	1,387,400	3,801	1,552,384	4,253
Red Earth	1,431,184	3,921	1,535,427	4,207
Taber South	1,462,228	4,005	1,356,414	3,716
Stettler	1,078,990	2,956	1,258,183	3,447
Ferrier	975,197	2,672	1,178,221	3,228
Sundre	1,087,302	2,978	1,132,326	3,102
Turner Valley (11)	1,070,883	2,933	1,069,745	2,931
Countess	991,409	2,716	1,065,457	2,919
Sylvan Lake	777,187	2,129	1,038,074	2,844
Cessford	1,084,831	2,972	1,018,990	2,792
Other fields and pools	32,182,045	88,170	41,348,002	113,809
Total	338,403,241	927,132	371,338,895	1,017,367
Total value ($)	876,886,679		1,050,889,073	
Saskatchewan[1]				
Total	89,486,610	245,169	88,445,497	242,316
Total value ($)	199,769,908		198,117,913	
British Columbia				
Boundary Lake (20)	9,404,380	25,765	9,703,989	26,586
Peejay (20)	5,083,086	13,926	4,425,895	12,126
Inga (21)	2,510,704	6,879	3,269,940	8,959
Milligan Creek (20)	3,912,798	10,720	3,152,309	8,636
Other fields and pools	4,567,005	12,260	4,716,281	12,907
Total	25,477,973	69,550	25,268,414	69,214
Total value ($)	60,943,312		60,442,046	
Manitoba				
North Virden Scallion (22)	2,895,762	7,934	2,775,062	7,603
Virden-Roselea (22)	1,480,398	4,056	1,388,623	3,804
Other fields and pools	1,532,229	4,202	1,440,047	3,948
Total	5,908,389	16,192	5,603,732	15,355
Total value ($)	14,858,129		14,091,705	

Table 1 (Continued)

(number in parenthesis gives location of field on the accompanying map)	1970		1971[p]	
	(barrels)	(bbl/day)	(barrels)	(bbl/day)
Ontario				
Total	1,048,168	2,872	958,272	2,625
Total value ($)	2,839,904		2,596,917	
Northwest Territories				
Total	846,003[2]	2,318	944,083[2]	2,587
Total value ($)	1,142,104		1,274,418	
New Brunswick				
Total	9,675	27	9,598	26
Total value ($)	13,544		13,437	
Total Canada	461,180,059	1,263,507	492,568,491	1,349,503
Total value ($)	1,156,453,580		1,327,425,509	

Sources: Statistics Canada and provincial government reports.
[1]Saskatchewan lists production by formation rather than by fields. [2]Net figure after allowing for reinjected products.
[p]Preliminary.

Table 2. Canada, production of natural gas liquids by province, 1970-71

	1970		1971[p]	
	(barrels)	(bbl/day)	(barrels)	(bbl/day)
Alberta				
Propane	20,158,510	55,229	22,954,256	62,888
Butane	13,114,578	35,930	14,751,919	40,416
Pentanes plus	41,894,798	114,780	44,500,051	121,918
Condensate	729,372	1,998	771,191	2,113
Total	75,897,258	207,937	82,977,417	227,335
Saskatchewan				
Propane	796,075	2,181	834,544	2,286
Butane	351,394	963	381,209	1,044
Pentanes plus	407,464	1,116	377,940	1,035
Total	1,554,933	4,260	1,593,693	4,365
British Columbia				
Propane	389,183	1,066	480,188	1,316
Butane	380,389	1,042	305,652	837
Pentanes plus	1,003,138	2,748	1,114,139	3,052
Condensate	116,637	320	109,008	299
Total	1,889,347	5,176	2,008,987	5,504

Table 2 (Continued)

	1970		1971^p	
	(barrels)	(bbl/day)	(barrels)	(bbl/day)
Canada				
Propane	21,343,768	58,476	24,268,988	66,490
Butane	13,846,361	37,935	15,438,780	42,298
Pentanes plus	43,305,400	118,645	45,992,130	126,006
Condensate	846,009	2,317	880,199	2,412
Total	79,341,538	217,373	86,580,097	237,206
Returned to formation	671,451	1,840	542,681	1,487
Total net production	78,670,087	215,533	86,037,416	235,719

Source: Provincial government reports. ^{p}Preliminary.

Table 3. Value of natural gas liquids by province, 1970-71

	1970	1971^p
	($ thousands)	
Alberta	154,017	196,433
Saskatchewan	2,709	2,694
British Columbia	3,384	3,376
Total, Canada	160,110	202,503
Volume (thousand bbl)	77,783	88,362

Source: Statistics Canada. ^{p}Preliminary.

According to the Alberta Energy Resources Conservation Board (AERCB), wellhead production capacity in Alberta was 1.64 million b/d which meant that about 62 per cent of the province's production capability was being utilized at the end of 1970.

Interest in developing Canada's Athabasca tar sands was revived this year and this can be attributed to three developments–potential crude oil price increases, the growing market acceptance of synthetic crude oil and a growing shortage of conventional oil. Operations at the Great Canadian Oil Sands Limited recovery plant near Fort McMurray, Alberta were made more efficient through modifications and new equipment and despite a maintenance shutdown in September, averaged better than 42,000 b/d for the year. In December of 1971 Syncrude Canada Ltd. received approval from the AERCB to increase the rate of production from their proposed bituminous sands plant to 125,000 b/d of synthetic crude oil and 5,500 b/d of residual fuel oil from a previously approved level of 80,000 b/d of synthetic crude oil and products. Syncrude is owned by four companies: Atlantic Richfield Canada Ltd., Canada-Cities Service, Ltd., Gulf Oil Canada Limited, and Imperial Oil Limited. The project would involve capital expenditures of around $360 to $430 million. Both the existing GCOS plant and the proposed Syncrude project utilize surface mining methods prior to processing the bituminous sands. However, since 90 per cent of the Athabasca sands are too deep for this type of surface development, Amoco Canada Petroleum Company Ltd. have reactivated their experimental plant in the Fort McMurray area which utilizes in-situ, fire-flood methods to cause the flow of bitumen from the tar sands, particularly in those areas where the thickness of overburden prohibits conventional mining.

In heavy oil recovery research, Imperial Oil Limited is initiating its fourth pilot project on their heavy oil acreage in the Cold Lake area of northwestern Alberta. This scheme will be a comprehensive test of the best recovery procedures the company has developed on its previous three pilots with the ultimate aim of finding out how much can be produced on a semicommercial scale of operation while gaining some appreciation for the costs of operating.

All of these projects are timed for completion to meet an anticipated short-fall in conventional Canadian crude oil production in the late 1970's.

Table 4. Canada, crude oil production, trade and refinery receipts, 1961-71

	Production[1]	Imports[2]	Exports[2]	Refinery Receipts[3] Domestic	Imports	Totals
	(bbl)	(bbl)	(bbl)	(bbl)	(bbl)	(bbl)
1961	220,848,080	133,249,113	65,222,523	157,182,263	133,225,748	290,408,011
1962	244,115,152	134,517,707	91,580,232	173,606,596	135,364,821	308,971,417
1963	257,661,777	147,720,870	90,875,816	186,157,830	146,586,964	332,744,794
1964	274,626,385	143,530,957	101,258,926	199,456,597	143,946,481	343,403,078
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[p]	492,568,491	244,971,778	270,770,498	263,274,665	244,224,822	507,499,487

Source: Statistics Canada.
[1] Alberta field condensate is excluded from the statistics for 1961 and 1962. [2] Trade of Canada (S.C.) data.
[3] Refinery receipts include condensate and pentanes plus.
[p] Preliminary.

Reserves

For the second consecutive year, Canada's net reserves of liquid hydrocarbons declined. The estimates of the Canadian Petroleum Association (CPA) place Canada's reserves of conventional crude oil and natural gas liquids at 10,162 million barrels at the end of 1971. This was comprised of 8,333 million barrels of crude oil and 1,829 million barrels of natural gas liquids. Reserves added in 1971 totalled 288 million barrels and of this amount, 207 million barrels were attributed to revisions, 63 million barrels to extensions of established fields, and 18 million barrels to new discoveries. Production of conventional crude oil and natural gas liquids totalled 564 million barrels in 1971 and exceeded additions to reserves by 276 million barrels. At the 1971 level of production, the life index for conventional crude oil and natural gas liquids dropped to 18 years, the lowest since the mid-1950's.

The reserve position of all provinces declined, the most notable reduction occurring in Alberta where total reserves dropped by 193 million barrels. The CPA estimated Alberta's remaining recoverable reserves of crude oil at 7,350 million barrels and natural gas liquids at 1,783 million barrels. Together, this accounted for about 90 per cent of Canada's proven reserves. Saskatchewan's reserves of liquid hydrocarbons declined from 692.4 million barrels to 648.9 million barrels, the decline being about 50 per cent of the total provincial annual production of 87 million barrels.

Probably the most noteworthy feature of the CPA reserve estimate this year is that new discoveries accounted for only 18 million barrels of additions to reserves, the remainder being due to revisions and extensions of existing fields. Reserves from the frontier regions of the north and Atlantic offshore are not

Table 5. Canada, year-end reserves of crude oil, 1970-71

Province or Region	1971	% of Total 1970	1971	Net Change 1971 over 1970
	('000 bbl)			('000 bbl)
Alberta	7,350,582	87.5	88.2	−144,985
Saskatchewan	630,634	8.0	7.6	−51,158
British Columbia	248,549	3.2	3.0	−22,950
Northwest Territories	43,922	0.5	0.5	−1,278
Manitoba	55,417	0.7	0.6	−4,536
Eastern Canada	3,983	0.1	0.1	−986
Total	8,333,087	100.0	100.0	−225,893

Source: Canadian Petroleum Association.

Table 6. Canada, reserves of liquid hydrocarbons at end of 1971

	Natural Gas Liquids	Crude Oil Plus Natural Gas Liquids	% of Total
	('000 bbl)	('000 bbl)	
Alberta	1,783,751	9,134,333	89.9
Saskatchewan	9,152	639,786	6.3
British Columbia	36,542	285,091	2.8
Other areas	–	103,322	1.0
Total	1,829,445	10,162,532	100.0

Source: Canadian Petroleum Association. – Nil.

included in these estimates because a lack of sufficient data precluded any meaningful estimate. Estimates of proved nonconventional reserves were again reported as a separate category by CPA and placed at 6.3 billion barrels, down slightly from the previous year. These reserves include only the synthetic crude oil that is considered to be recoverable within an "economic radius" of the province's only existing oil sands plant near Fort McMurray, and are based on the concept that the deposits within this radius may be expected to have equivalent or better characteristics than the deposits currently under development. Ultimate recoverable reserves for Athabasca-type oil sands by all known methods of recovery have been estimated by the Alberta Energy Resources Conservation Board at over 300 billion barrels.

Exploration and development

Alberta. In Alberta, both the footage drilled and the wells completed increased this year but this can be mainly attributed to the revival of interest in exploring for shallow gas in the southern areas of the provinces. Drilling statistics show that development drilling increased 7 per cent to 3.58 million feet and exploratory drilling decreased 4 per cent to 4.29 million feet. There were oil discoveries in 1971 but all were in the small to medium class and no new exploratory trends were outlined. However, several discoveries in southern Alberta of medium and heavy gravity oil served to re-emphasize the importance of this region as a future contributor to provincial reserves. The best oil find of this kind, indeed the best in recent years, was discovered in the Grand Forks area in southeastern Alberta in the Lower Mannville sandstone of Lower Cretaceous age. By year-end, the Alberta Energy Resources Conservation Board, on the data available, rated the field as having about 80.5 million barrels of oil in place with the north and south limits of the Grand Forks field still to be defined. There is no doubt that additional reserves will be found before the field is fully developed. The discovery of a field of this magnitude in southern Alberta is certain to give the industry cause to re-evaluate the potential of this area and provide the impetus for a significant increase in future exploratory and development activity. Elsewhere in southern Alberta, several other discoveries were recorded during the year, the most important of these being a Glauconitic zone find in the Countess-Lathom area discovered late in 1970 and currently being developed. Another significant discovery has apparently been made in the Claresholm area but since the well is still on the confidential list, details as to producing formation and potential are not available. In central-west Alberta, the Meekwap field continued to hold the exploration spotlight during 1971 as step-out drilling expanded the established field limits. The producing zone in this area is the Devonian, Nisku Formation and a discovery 3 miles northeast of the Meekwap field boundary has apparently located a separate Nisku pool. As a result of current successes, the exploration programs of the companies operating in the area have been expanded 25 miles to the north. At year-end several exploratory wells were being drilled, the results of which will have an important bearing on future development. In addition to a Granite Wash oil discovery, a Swan Hills discovery has also been reported immediately to the west of the Red Earth field in north-central Alberta, but details as to the importance of these are still confidential.

In northwestern Alberta, the Shekilie River region, situated immediately northwest of the Zama oil and gas producing field, continued to receive industry attention during 1971. The initial discovery was made in 1970 and 4 successful step-out wells were completed during 1971. It is believed that the producing formation is the Middle Devonian Keg River Formation but there has been very little detail as to net pays and producibility released by the operator to date. Further drilling is contemplated in this area. Exploratory drilling continued at a reduced level in the Zama and Rainbow Lake areas, mainly within the field boundaries, and was rewarded with some success.

Most of the oilfield development drilling in the province continued to be concentrated in the Zama-Virgo-Rainbow fields of northwestern Alberta. The remainder of the development drilling was confined to infill drilling within the boundaries of Mitsue, Nipisi and Utikuma Lake fields. There were no major extensions to existing fields via the development drilling route. The increase in development drilling footage in 1971 can be mainly attributed to gas field development, not oilfield.

There were no major enhanced recovery projects implemented during the year, chiefly because there have been no major oil discoveries since 1966. As a result most major fields have secondary recovery programs already installed and there are only a few minor projects still to be done. Most of the significant waterflood projects that were completed this year were confined to the Rainbow Lake and Zama Lake

Table 7. Canada, wells completed and footage drilled

	1955		1960		1970		1971	
	(No.)	(ft)	(No.)	(ft)	(No.)	(ft)	(No.)	(ft)
Western Canada								
Westcoast-offshore								
New field wildcats	–	–	–	–	–	–	–	–
Hudson Bay-offshore								
New field wildcats	–	–	–	–	–	–	–	–
British Columbia								
New field wildcats	34	194,014	60	365,818	43	252,896	21	122,680
Other exploratory	2	13,020	11	55,749	53	245,985	76	396,127
Development	–	–	72	331,740	81	401,051	91	431,488
	36	207,034	143	753,307	177	899,932	188	950,295
Alberta								
New field wildcats	307	1,773,980	338	2,078,876	282	1,625,921	256	1,211,908
Other exploratory	105	436,941	223	1,171,079	740	2,825,799	757	3,088,273
Development	1,208	6,219,810	1,131	7,125,856	802	3,325,273	977	3,585,434
	1,620	8,430,731	1,692	10,375,811	1,824	7,776,993	1,990	7,885,615
Saskatchewan								
New field wildcats	312	1,182,727	113	468,507	110	308,474	112	375,883
Other exploratory	50	179,511	28	99,203	285	772,530	269	677,400
Development	550	1,873,040	461	1,795,968	538	1,398,639	360	954,226
	912	3,235,278	602	2,363,678	933	2,479,643	741	2,007,509
Manitoba								
New field wildcats	59	174,313	10	30,505	12	37,365	4	13,731
Other exploratory	10	23,743	3	6,370	2	5,344	6	4,817
Development	292	647,379	54	110,073	5	12,017	5	13,880
	361	845,435	67	146,948	19	54,726	15	32,428
Territories								
New field wildcats	9	12,266	32	105,969	69	355,383	75	464,961
Other exploratory	–	–	–	–	1	6,327	1	3,055
Development	–	–	–	–	–	–	–	–
	9	12,266	32	105,969	70	361,710	76	468,016
Total, western Canada								
New field wildcats	718	3,337,300	553	3,049,675	516	2,580,039	468	2,189,163
Other exploratory	167	653,215	265	1,332,401	1,023	3,855,985	1,064	4,169,672
Development	2,050	8,740,229	1,718	9,363,637	1,484	5,136,980	1,478	4,985,028
	2,935	12,730,744	2,536	13,745,713	3,023	11,573,004	3,010	11,343,863
Eastern Canada								
Eastcoast-offshore								
New field wildcats	–	–	–	–	14	149,220	19	204,366
					14	149,220	19	204,366
Ontario								
New field wildcats	64	112,246	39	68,393	61	132,739	55	111,128
Other exploratory	57	92,536	55	109,839	10	14,413	19	23,675
Development	266	271,191	213	228,190	98	160,990	66	115,516
	387	475,973	307	406,422	169	308,142	140	250,319
Quebec								
New field wildcats	9	10,226	5	4,287	4	35,757	5	28,555
Other exploratory	–	–	–	–	–	–	–	–
Development	–	–	1	240	–	–	–	–
	9	10,226	6	4,527	4	35,757	5	28,555

Table 7 (Continued)

	1955		1960		1970		1971	
	(No.)	(ft)	(No.)	(ft)	(No.)	(ft)	(No.)	(ft)
New Brunswick								
New field wildcats	1	3,414	2	13,023	–	–	1	4,416
Other exploratory	–	–	–	–	–	–	–	–
Development	7	21,143	–	–	–	–	–	–
	8	24,557	2	13,023	–	–	1	4,416
Nova Scotia								
New field wildcats	–	–	1	9,840	–	–	–	–
Other exploratory	–	–	–	–	–	–	–	–
Development	–	–	–	–	–	–	–	–
	–	–	1	9,840	–	–	–	–
Newfoundland								
New field wildcats	1	1,381	–	–	–	–	–	–
Other exploratory	–	–	–	–	–	–	–	–
Development	–	–	–	–	–	–	–	–
	1	1,381	–	–	–	–	–	–
Total, eastern Canada								
New field wildcats	75	127,267	47	95,543	79	317,716	80	348,465
Other exploratory	57	92,536	55	109,839	10	14,413	19	23,675
Development	273	292,334	214	228,430	98	160,990	66	115,516
	405	512,137	316	433,812	187	493,119	165	487,656
Total Canada								
New field wildcats	793	3,464,567	600	3,145,218	595	2,897,755	548	2,537,628
Other exploratory	224	745,751	320	1,442,240	1,092	3,870,398	1,083	4,193,347
Development	2,323	9,032,563	1,932	9,592,067	1,582	5,297,970	1,544	5,100,544
Total	3,340	13,242,881	2,852	14,179,525	3,210	12,066,123	3,175	11,831,519

Source: Canadian Petroleum Association. – Nil.

areas and late in the year the Alberta Energy Resources Conservation Board approved a waterflood project by Aquitaine Company of Canada Ltd. for the three principal Rainbow South, Keg River A.E. and G. oil pools. When this is completed, recovery is expected to be increased to 60 per cent, or 83 million barrels of the original 138 million barrels of oil in place.

Saskatchewan. Both exploratory and development drilling footage in Saskatchewan declined for the second year. Development drilling, at 954,000 feet declined 32 per cent from the previous year. Exploratory drilling, at 1.05 million feet, was down 3 per cent. Most of the development drilling was again concentrated in two areas of western Saskatchewan: Lloydminster in the north and Battrum in the south where fields are still being actively developed. At Lloydminster, the Dulwich, Northminster and Lashburn fields in particular were enlarged by development drilling while the Butte and Suffield fields in the Jurassic trend of southwestern Saskatchewan had some minor extension.

There is little else to report in the way of significant industry developments in Saskatchewan during 1971. Probably the most noteworthy discovery reported was the Jurassic oil strike in the Cypress Hills area in the southwestern corner of the province, where it was reported that a well tested oil from the Jurassic, Gravelbourg Formation. The well is still on the confidential list but is of interest because it may be the forerunner of a new producing trend in the province.

Manitoba. Aggregate development and exploratory drilling again declined this year as only 15 wells were drilled for a total drilling footage of 32,400 feet. Of this amount 18,500 were exploratory footage and 13,900 were development footage. There were no new discoveries and development drilling was essentially restricted to outlining marginally economic reserves around the peripheries of established fields.

Table 8. Canada, wells drilled, by province, 1970-71

	Oil		Gas		Dry[1]		Total	
	1970	1971	1970	1971	1970	1971	1970	1971
Western Canada								
Alberta	304	361	617	691	903	938	1,824	1,990
Saskatchewan	469	266	63	108	401	367	933	741
British Columbia	36	46	50	36	91	106	177	188
Manitoba	2	2	–	–	17	13	19	15
Yukon and N.W.T.	1	1	1	3	68	72	70	76
Westcoast-offshore	–	–	–	–	–	–	–	–
Hudson Bay-offshore	–	–	–	–	–	–	–	–
Subtotal	812	676	731	838	1,480	1,496	3,023	3,010
Eastern Canada								
Ontario	10	2	63	47	96	91	169	140
Quebec	–	–	–	–	4	5	4	5
Atlantic provinces	–	–	–	–	–	–	–	–
Eastcoast-offshore	–	–	–	1	14	18	14	19
Subtotal	10	2	63	48	114	114	187	164
Canada	822	678	794	886	1,594	1,610	3,210	3,174

Source: Canadian Petroleum Association.
[1]Includes suspended wells. – Nil.

British Columbia. Both exploratory and development drilling increased slightly in 1971. Exploratory drilling amounted to 519,000 feet, 20,000 feet more than in 1970 and development drilling increased by 30,000 feet to 431,000. The expectation that the Triassic oil discovery, reported early in the year, might have proven up a new producing trend in the Flat Rock area of northeastern British Columbia has not been realized as several step-out wells drilled in the same area were dry and abandoned. As a result, exploratory effort in the Flat Rock area has come to a standstill.

Table 9. Oil wells in western Canada at end of year, 1970-71

	Producing Wells		Wells Capable of Production	
	1970	1971	1970	1971
Alberta	9,383	9,467	13,971	14,065
Saskatchewan	6,177	6,177	7,287	7,314
Manitoba	730	695	904	900
British Columbia	529	556	640	677
Northwest Territories and Arctic islands	44	37	63	63
Total	16,863	16,932	22,865	23,019

Source: Provincial and federal government reports.

Most development drilling was confined to the Boundary Lake Triassic pool where several infill wells were drilled during the year. A few development wells were also drilled on the edge of the Inga field, enlarging its boundaries.

Yukon Territory, Northwest Territories and Arctic islands. The pace of exploratory effort in the Territories and the Arctic islands quickened during 1971 and on the basis of preliminary reports, was rewarded by several significant oil and gas discoveries. Exploratory drilling in these regions increased by 30 per cent to 468,000 feet. In the Mackenzie Delta area, Imperial Oil Limited's exploration program which began in 1970 has so far yielded two oil finds on the Tuktoyaktuk Peninsula and two gas-condensate strikes in the Mackenzie Delta. Two of these discoveries were made this year when the company initiated a five-rig drilling program. The first discovery, IOE Mayogiak on Tuktoyaktuk Peninsula, recovered oil and gas from two separate zones, the lower of which flowed oil from a depth of 9,400 feet. The gas strike, IOE Taglu G-33 was made on Richards Island in the Mackenzie Delta. Here a large flow of gas was encountered during a drill-stem test of a zone at a depth of 8,100 feet. In addition, a considerable amount of condensate was recovered with the gas. Early reports indicate this to be a multireservoir discovery. Then early in 1972 Imperial Oil announced that a preliminary evaluation had indicated a hydrocarbon-bearing zone in its Mallik L-38 well, located about 8½ miles northeast of the company's Taglu well. Mallik is reported to have penetrated several hundred feet of hydrocarbon-bearing reservoirs in two separate groupings. In addition, Taglu West, drilling 3 miles west of the Taglu G-33 well, has also encountered hydrocarbons in the same interval as the discovery. Neither of these wells has yet been fully evaluated, and until this is done the size and extent of the finds can only be surmised. These discoveries are most encouraging and do point up the potential of the region, although it is much too early to predict if reserves are large enough to justify a pipeline system. However, the extensive exploration drilling programs being conducted this winter by companies operating in the area, should provide a good indication of what the answer to this question will be.

In the Arctic islands, Panarctic Oils Ltd., the industry-government company, continued to dominate the exploration picture and was rewarded by another natural gas discovery at Kristoffer Bay on Ellef Ringnes Island, approximately 50 miles north of King Christian Island, site of an earlier discovery by Panarctic. This is the third natural gas discovery made by Panarctic in the Arctic islands since it began its exploratory program 4 years ago, and although there has been nothing officially revealed about the magnitude of the discovery, early indications are that it too is large. The two previous discoveries, the first on Melville Island in 1969 and the second late in 1970 on King Christian Island, are considered by some authorities to be major fields, although additional development drilling will be required before such a view can be confirmed.

In February of 1972 Panarctic made the first oil discovery in the Arctic islands at its Romulus C-42 well drilling on the Fosheim Peninsula on Ellesmere Island. While it is too early to predict the commercial importance of the test, it is significant when it is considered that oil discovered in commercial quantities in this area could be moved during many months of the year by pipeline to ports on the east coast of the island and thence to eastern North American markets by ship. This would result in a greatly increased level of exploration activity in this region.

Panarctic is the largest landholder in the Arctic islands, retaining under permit approximately 60 million acres at the end of 1971. To defray the high operating costs in Arctic areas, Panarctic entered into farmout agreements with several oil companies during the past year, including Imperial Oil and Sun Oil Company. Increased participation by the major oil companies will also contribute to an escalation in exploration activity in this area during the coming year.

Eastern Canada. In Ontario both exploratory and development drilling declined. Exploratory drilling at 135,000 feet was down 8 per cent from the previous year and development footage, at 116,000 feet, declined 28 per cent. There were no significant discoveries made in 1971 but at the end of the year exploratory activity along a shallow Devonian trend seemed to be attracting industry interest, as an extensive drilling program was started by one operating company in the London area. A water injection scheme installed in the Willey field late in 1971, is expected to increase ultimate recoverable crude oil from this pool to 1.5 million barrels.

In northern Ontario, the James Bay Lowlands area has attracted some industry interest. Aquitaine Company of Canada Ltd. drilled two wells near Sandbank Lake, approximate location 51°4′N, 82°36′W. One well was abandoned at a depth of 1945 feet and the other was suspended because of technical difficulties. Early in 1972 it was reported that Consumers Gas Company had commenced drilling another exploratory well about seventy miles to the northeast of the Aquitaine wells. In Hudson Bay, Aquitaine and its associates have ordered a new specially constructed offshore drilling rig for operations on their extensive land holdings in the Bay, scheduled to commence in the summer of 1973. The rig is presently under construction in a United States shipyard.

In Quebec, three exploratory wells were drilled this year and all were dry and abandoned. Aquitaine drilled a deep test near Montreal to evaluate Silurian and Ordovician formations and the other two wells were drilled by Husky Oil Ltd. in the Trois-Rivières area.

The persistent search for oil and gas off Canada's east coast was rewarded by the discovery of an oil and gas bearing structure in a well drilled by Mobil Oil Canada, Ltd. and Texas Eastern Transmission Corporation, on the western tip of Sable Island 175 miles east of Halifax, Nova Scotia. The discovery well was reported to have penetrated twelve zones which flowed both natural gas and condensate at rates up to 10.6 million cubic feet a day of gas and 1,600 barrels a day of condensate. Four zones flowed crude oil at a rate of 367 barrels to 575 barrels a day and other zones are interpreted to be productive but have not been tested. These flow tests rank with those of the best wells ever completed anywhere in Canada, but the actual potential of the pool will not be known until further development drilling is done. An earlier well drilled 10 miles to the east in 1967 had only noncommercial indications of gas. Since that time, there have been 29 other wells completed off the coast of Nova Scotia with two others still drilling at the end of 1971. Several of these wells also had noncommercial shows of oil and gas.

Elsewhere in this area, the well Tenneco et al Leif E-38, the first well ever to be drilled offshore on the Labrador Shelf, had to be suspended before it reached total depth because of poor weather and rough sea conditions. This test was located about 510 miles north and slightly west of St. John's, Newfoundland. Plans for two other tests scheduled to be drilled by the same operator in this area were also suspended because of operating conditions similar to those encountered by the first well. Since 1966 there have been six wells drilled off the south coast of Newfoundland and two more were still drilling at year-end but thus far, none has found hydrocarbons. However, the discovery at Sable Island will assuredly provide impetus for increased industry activity along the entire eastern seaboard and in this connection, a fourth semisubmersible drilling rig is now under construction in the Halifax shipyards and is scheduled for completion late in 1972.

Transportation

A total of 703 miles of new crude oil and products pipeline was put into operation in 1971, as pipeline construction increased appreciably over that of the previous year. Most of the major pipeline projects completed in 1971 were product transmission systems. Nevertheless, Interprovincial Pipe Line Company added 81 miles of 20-inch loop in two sections of its main line between Sarnia and the Welland Canal. Sixty-six pumping units were added between Edmonton and Sarnia, raising mainline capacity to a system high of 1,308,000 barrels daily out of Cromer, Manitoba. The completion of the 1971 pumping additions increased the capacity of the line between Edmonton, Alberta and Superior, Wisconsin to the maximum practicable, short of beginning construction of a fourth line. In this regard, Interprovincial will commence looping with 48-inch pipe in 1972. When the system has a complete 48-inch line, Interprovincial's capacity will be increased by over 2 million barrels daily, which is more than double what it is now. At the end of 1971 the Interprovincial system consisted of 5,237 miles of pipeline with storage facilities of over 12 million barrels at 14 sites. Murphy Oil Company Ltd. placed their dual crude oil-condensate pipeline from Kerrobert, Saskatchewan to the Lloydminster field in operation in 1971 and throughput averaged 5,542 barrels a day over the nine months of operation.

Table 10. Mileage in Canada of pipelines for crude oil, natural gas liquids and products

Year-end	Miles	Year-end	Miles[1]
1957	6,873	1964	11,744
1958	7,148	1965	12,315
1959	7,945	1966	15,705
1960	8,435	1967	16,863
1961	9,554	1968	17,550
1962	10,037	1969	18,055
1963	10,607	1970	18,588
		1971[p]	19,291

Source: Statistics Canada.
[1]Includes producers' gathering lines for years 1966 to 1971. [p]Preliminary.

Table 11. Deliveries of crude oil and propane by company and destination, 1970-71

Company and Destination	1970	1971
	(millions of barrels)	
Interprovincial Pipe Line		
Western Canada	42.5	42.4
United States	147.4	142.6
Ontario	138.9	171.8
Total	328.8	356.8
Trans Mountain Oil Pipe Line		
British Columbia	35.6	38.5
State of Washington	81.8	79.3
Westridge Terminal	4.2	3.6
Total	121.6	121.4

Source: Company annual reports.

Among the important product pipeline additions was Dome Petroleum Limited's pipeline from the Empress, Alberta gas processing plant to the Kerrobert, Saskatchewan pumping station on the Interprovincial main line. Ninety-four miles of 8-inch line were installed in this operation. Another major products pipeline was completed when Imperial Oil, in Alberta added 107 miles of 8-inch pipeline from the Judy Creek gas processing plant to the Golden Spike oil field terminal. Other important products pipelines constructed during the year included the looping of the main section of Dome's LPG-condensate pipeline between Cochrane, Alberta and Edmonton, entailing the laying of 116 miles of 10-inch pipe from Rocky Mountain House to the Edmonton terminal. In Ontario, Sun-Canadian Pipe Line Company Limited completed looping 60 miles of 8- to 12-inch pipeline in their Sarnia-Toronto system.

Early in 1972 Dome applied to the National Energy Board for approval to construct a 2,000-mile pipeline from Edmonton to Sarnia via the United States to carry light liquid hydrocarbons. Under this scheme Dome would supply not only its own fractionation plant, which it would build at Sarnia, but export an additional 111 million barrels of propane and 139 million barrels of ethane over a 10-year period to two United States firms. The Dome application if successful, would initiate the first export by Canada of liquid ethane extracted from natural gas. The plan envisages a new line from Edmonton, Alberta to Sarnia, Ontario, capable of carrying initially 160,000 b/d of ethane and propane. A second line from Empress, Alberta would join the line at Kerrobert, Saskatchewan. Dome envisions the system as a $320 million marketing and transportation system for light liquid hydrocarbons.

Northern pipeline research institutions in Canada made excellent progress in solving the ecological, environmental and operating problems related to constructing pipelines in permafrost areas. Three major groups have now been engaged in basic northern pipeline research for periods varying up to 2 years. Two of these projects, Gas Arctic Systems and the Northwest Project Study Group, are concerned with natural gas transportation while the third, Mackenzie Valley Pipe Line Research Limited is conducting research on northern oil pipeline construction. Mackenzie Valley is comprised of several oil and pipeline companies and the principal subject of investigation on operational problems has been the thermal response of permafrost to a warm-oil pipeline. A 2,000-foot test section of 48-inch pipeline was laid in an area near Inuvik, Northwest Territories in 1969 and the trials are still continuing. By the end of 1971 all three research groups were unanimous in the opinion that the problems will be solved and the pipelines built, providing that sufficient reserves are found in northern areas to provide the economic incentives.

There were very few changes in pipeline tariffs during the year as most of the larger pipeline systems retained the price structures of the previous year. One exception was Rangeland Pipeline Division of the Hudson's Bay Oil and Gas Company Limited which introduced a joint tariff on LPG's from the South Lone Pipe Creek Gas Plant to Sundre Station and Rimbey of 37.0¢ and 38.5¢, respectively.

Petroleum refining

Canadian refinery capacity experienced a significant increase in 1971 as three large new refineries came on stream and major expansions to existing plants were carried out. Crude oil capacity of all plants in Canada totalled 1,675,000 b/d, which represents an increase of 323,250 b/d over the 1970 capacity. Although this is a substantial increase in the country's ability to refine crude oil, the number of operating refineries remained at 40 as three small plants were closed in western Canada.

Table 12. Crude oil refining capacity by regions

	1970		1971	
	(bbl/day)	(%)	(bbl/day)	(%)
Atlantic provinces	135,100	9.9	294,300	17.6
Quebec	460,600	34.1	577,500	34.5
Ontario	389,200	28.8	389,200	23.2
Prairies and Northwest Territories	241,550	17.9	288,700	17.2
British Columbia	125,800	9.3	125,800	7.5
Total	1,352,250	100.0	1,675,500	100.0

Source: Department of Energy, Mines and Resources, Petroleum Refineries in Canada (Operators List 5), January 1972.

In the Atlantic provinces, Gulf Oil Canada Limited's 80,000 b/d Point Tupper refinery was put on stream early in 1971 and reached full capacity late in the year. The refinery is designed to produce residual fuel oil, gasoline, aviation turbine fuel and distillate. The bulk of these products will be consumed locally and the remainder will serve United States east coast markets. Site preparation for the Newfoundland Refining Company Limited's 100,000 b/d refinery at Come-By-Chance in Newfoundland began this winter and it is expected to start up late in 1973. The Federal Government is assisting in both the financing and construction of a 3,400-foot dock which when completed, will be capable of handling the largest oil tankers in the world. In New Brunswick, the expansion program at Irving Refining Limited's refinery in Saint John was completed this year when capacity was increased from 45,000 b/d to 120,000 b/d.

Golden Eagle Canada Limited's 100,000 b/d refinery at St-Romuald near Quebec City, came on stream late in 1971. This refinery is designed to produce light and heavy fuel oils, gasoline, asphalt and liquid petroleum gases. The present all-weather dock is capable of accommodating tankers up to 100,000 dwt. Planned modifications to the port would permit the handling of still larger ships. The refinery features the latest in pollution control installations including a waste-water holding basin, an air flotation unit to assist in skimming oil waste from runoff water, and also sulphur emission controls.

On the Prairies, construction of Gulf Oil Canada Limited's 72,000 b/d refinery at Edmonton was finished in mid-1971. With the completion of this refinery, Gulf has virtually accomplished the major reorganization of their Prairie refining and marketing operations which began in 1969 with the closing of their small Brandon, Manitoba plant. The company closed down its Saskatoon refinery in October and at about the same time, its Moose Jaw and Calgary refineries were converted to asphalt plants. The new Edmonton refinery has not only become the company's chief source of gasoline, diesel and heating fuel in the Prairie Provinces, it has also contributed an increase of about 52,000 b/d of refinery capacity to the region. This refinery also incorporates several of the latest features in processing units including a 40,000 b/d bulk desulphurizer designed to manufacture products with a sulphur content below existing air pollution standard requirements. In addition, the refinery has been provided with the latest in air and stream pollution controls, including a 300-foot smokeless flare and an effluent disposal well. Henceforth, Gulf will distribute its products to their Prairie markets using a new products pipeline from Edmon-

Table 13. Canada, crude oil received at refineries, 1970 and 1971^p

Location of Refineries	Year	Country of Origin							
		Canada	Middle East	Trinidad	Venezuela	Africa	Colombia	Others	Total Received
		(bbl)	(bbl)	(bbl)	(bbl)	(bbl)	(bbl)	(bbl)	(bbl)
Atlantic provinces	1970	590	13,926,789	–	36,035,231	–	233,113	–	50,195,723
	1971^p	591	28,881,537	–	36,405,561	–	272,731	7,754,747	73,315,167
Quebec	1970	–	35,796,591	220,370	96,596,608	17,782,046	7,290,509	–	157,686,124
	1971^p	–	28,025,166	–	110,983,635	24,126,919	7,365,877	–	170,501,597
Ontario	1970	134,891,748	–	–	458,596	–	–	–	135,350,344
	1971^p	135,513,609	–	–	408,649	–	–	–	135,922,258
Prairies	1970	79,278,406	–	–	–	–	–	–	79,278,406
	1971^p	80,704,216	–	–	–	–	–	–	80,704,216
British Columbia	1970	43,903,051	–	–	–	–	–	–	43,903,051
	1971^p	46,141,994	–	–	–	–	–	–	46,141,994
Northwest and Yukon Territories	1970	892,549	–	–	–	–	–	–	892,549
	1971^p	914,255	–	–	–	–	–	–	914,255
Total	1970	258,966,344	49,723,380	220,370	133,090,435	17,782,046	7,523,622	–	467,306,197
	1971^p	263,274,665	56,906,703	–	147,797,845	24,126,919	7,638,608	7,754,747	507,499,487

Source: Statistics Canada. ^{p}Preliminary; – Nil.

ton to Calgary and serve the remainder of its Prairie customers as far east as Winnipeg by the Interprovincial pipeline system.

Elsewhere on the Prairies, Husky Oil Ltd. has converted its Lloydminster refinery to produce asphalt only. Under an agreement with Gulf, Husky will provide Gulf with substantial quantities of asphalt in return for diesel fuel and gasoline from Gulf's Edmonton refinery. Husky has also closed its small refinery at Moose Jaw, Saskatchewan. Imperial Oil announced this year that it intended to begin a $200 million revamping of its petroleum product supply system in the Prairie Provinces. This project will involve the construction of a new 140,000 b/d installation at Edmonton to be called the Strathcona refinery and the closing of existing plants in Calgary, Regina, Winnipeg and Edmonton. The new refinery will be built on the site of the present facility and will give Imperial Oil a net increase in capacity of 29,000 barrels daily after the others are closed down. New product terminals will be built at major Prairie centres and supplied from the Edmonton refinery through existing pipeline systems.

Imperial Oil Enterprises Ltd. remained the largest refiner in Canada. The company's nine refineries comprise 27 per cent of Canadian refinery capacity. Gulf Oil Canada Limited's seven plants constitute 18 per cent of Canadian refinery capacity and Shell Canada Limited, third largest refiner, operates six refineries which account for 14 per cent of the total.

Marketing and trade

Receipts of crude oil and equivalent at Canadian refineries totalled 1.39 million barrels daily in 1971, 8.6 per cent more than in 1970. Refineries in western Canada and Ontario increased their crude oil consumption by only 3.2 per cent, taking an average of 720,000 barrels of Canadian oil daily. On the other hand, deliveries of imported crude oil to refineries in Quebec and the Maritime Provinces rose 17 per cent to 670,000 b/d in 1971. Much of this increase is attributable to the recent start-up of operations at the large new refineries of St-Romuald, Quebec and Point Tupper, Nova Scotia. These refineries were partly designed to meet the large markets in Ontario and Quebec for light and heavy fuel oils which have in the past been largely served by products imported from Venezuela and the Netherlands Antilles. As a result product imports into Canada last year declined to 148,000 b/d, which is about 46,000 b/d less than the previous year and now represents only about 8.8 per cent of Canada's present ability to refine crude oil. It is likely that product imports will again markedly decrease in 1972.

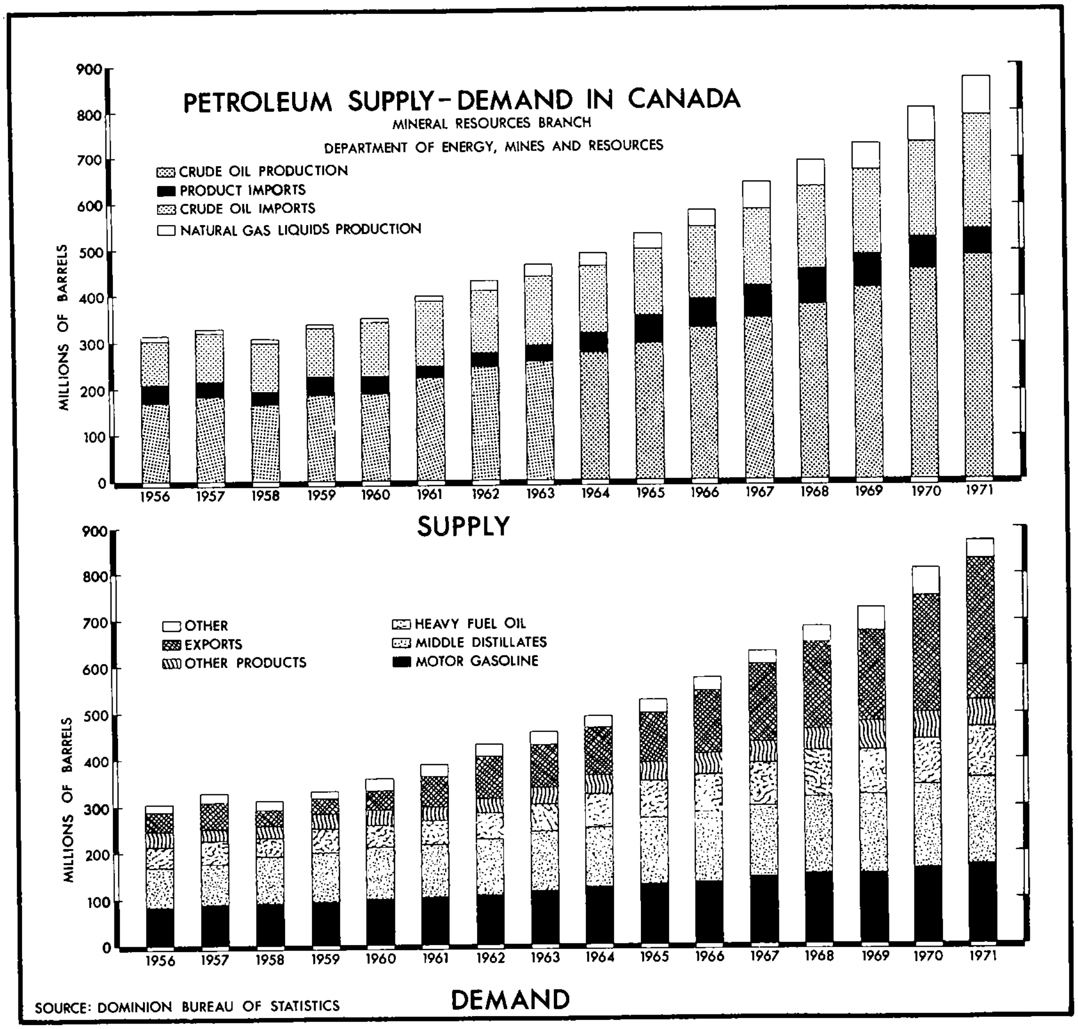
Venezuela was again the main source of imported crude oil, increasing its exports to Canada by 11 per cent to 406,000 b/d. Middle East countries more than maintained their annual shipments of crude oil to Canada in 1971 as they exceeded 156,000 b/d. Nigeria also continued to increase its share of the Canadian import market, shipping over 66,000 b/d to this country for a 13.5 per cent gain over the previous year. Columbia, at 21,000 b/d, also contributed significantly to Canada's import requirements.

Exports to the United States of crude oil and equivalent increased by 12.4 per cent to 742,000 barrels daily in 1971–slightly less than anticipated. The strong growth in demand for Canadian crude oil by United States refiners east of the Rockies (District 1-4) was partly offset by a decrease in exports to Puget Sound refiners (District 5). Exports to markets in the northeastern states, primarily via Interprovincial's main line, amounted to 524,000 b/d, an increase of 88,000 b/d over 1970 shipments. Canadian exports to the United States Puget Sound region via Trans Mountain Oil Pipe Line Company, declined by

Table 14. Regional consumption of petroleum products by province, 1971[p]

	Motor Gasoline	Kerosene Stove Oil Tractor Fuel	Diesel Fuel Oil	Light Fuel Oils No. 2 and 3	Heavy Fuel Oils No. 4, 5 and 6
	(thousands of barrels)				
Newfoundland	2,630	1,393	2,944	2,554	5,655
Maritimes	11,770	3,356	4,332	11,865	22,168
Quebec	41,694	6,145	8,420	36,610	43,750
Ontario	64,713	3,421	11,560	40,256	27,781
Manitoba	8,055	1,159	2,929	1,769	1,125
Saskatchewan	10,429	1,145	4,203	1,510	537
Alberta	17,163	539	6,657	821	411
British Columbia	17,797	1,900	8,737	6,758	8,574
Northwest and Yukon Territories	591	346	1,490	732	142
Total	174,842	19,404	51,272	102,875	110,143

Source: Statistics Canada. [p]Preliminary.



6,000 b/d to 218,000 b/d, reflecting a sharp reduction in tanker rates which improved the competitive position of offshore oil. The United States Government has raised the 1972 quota for imports of Canadian crude oils into Districts 1-4 to 540,000 b/d. Natural gas liquids are not included in this quota and are likely to be imported at about 80,000 b/d in 1972. United States refiners in the north-central states will also be permitted to exchange some of their offshore import quotas for Canadian oil but it is not anticipated that this ruling will significantly contribute to increased Canadian exports.

Exports of petroleum products increased by 41 per cent to 100,000 b/d in 1971. This large increase is primarily due to a significant rise in the amount of heavy fuel oil exported to the northeastern region of United States. The capacity of Quebec and Maritime refiners to serve part of this potentially large market was established this year when the large new refineries at St-Romuald, Quebec and Point Tupper, Nova Scotia came on stream. This capacity will be further increased when the 100,000 b/d refinery at Come-By-Chance, Newfoundland starts up in 1973. As in previous years, the principal products exported were butane and propane from natural gas processing plants. Exports of propane to Japan declined to 9,900 b/d from the previous year's total of 11,500 b/d. To summarize, imported oils' share of the Canadian market remained at about 53 per cent in 1971 but Canada, for the first time, became a net exporter of

Table 15. Canada, exports and imports of refined petroleum products, 1970-71

	Exports		Imports	
	1970	1971p	1970	1971p
	(millions of barrels)			
Propane and butane	20.77	23.49	0.25	0.06
Aviation gasoline	0.01	–	0.12	0.08
Motor gasoline	0.87	0.61	5.40	4.72
Aviation turbo fuel	0.20	0.28	3.14	1.67
Kerosene, stove oil and tractor fuel	0.13	0.08	1.30	1.59
Diesel fuel oil	0.67	0.30	5.78	3.34
Light fuel oil #2 & 3	2.63	1.25	12.55	9.84
Heavy fuel oils #4, 5 & 6	0.50	9.64	36.81	29.70
Asphalt	0.16	0.03	0.37	0.38
Petroleum coke	0.03	–	3.18	0.02
Lubricating oils	0.01	0.01	1.19	1.24
Other products	0.01	1.02	0.60	1.34
Total all products	25.99	36.71	70.69	53.98

Source: Statistics Canada.
pPreliminary; – Nil.

Table 16. Canada, supply and demand of oils 1970-71

	1970	1971p
	(thousands of barrels)	
Supply		
Production		
Crude oil and condensate	461,180	492,568
Other natural gas liquids	77,783	85,157
Net production	538,963	577,725
Imports		
Crude oil	207,633	244,972
Products	70,690	53,980
Total imports	278,323	298,952
Change in stocks		
Crude and natural gas liquids	−2,228	−1,485
Refined petroleum products	−2,358	−6,187
Total change	−4,586	−7,672
Oils not accounted for	+205	+3,256
Total supply	812,905	872,261
Demand		
Exports		
Crude oil	240,894	270,770
Products	25,990	36,710
Total	266,884	307,480
Domestic sales		
Motor gasoline	166,060	173,776
Middle distillates	180,020	187,713
Heavy fuel oil	106,555	109,431
Other products	56,426	58,279
Total	509,061	529,199
Uses and losses		
Refining	34,787	33,585
Field, plant and pipeline	2,173	1,997
Total	36,960	35,582
Total demand	812,905	872,261

Sources: Statistics Canada, and provincial government reports.
pPreliminary.

crude oil and petroleum products, as exports exceeded imports by 8.5 million barrels.

On the international scene, OPEC nations negotiated higher crude oil prices for member nations and at year-end they obtained an additional 8.49 per cent increase in posted prices of crude oil to compensate for losses incurred as a result of the devaluation of the United States dollar and other western currency changes. The six Persian Gulf OPEC countries are Abu Dhabi, Iran, Iraq, Kuwait, Saudi Arabia and Quatar.

Outlook

Continuing strong demand for Canadian oil in both Canadian and export markets can be expected to continue into the foreseeable future and steadily increase production levels above total domestic consumption. It is also likely that expansion will continue in all other sectors of the industry, including exploration, processing and transportation. The spreading search for oil and gas in Canada and the remarkable success ratio attained in the northern regions and offshore in such a short period is highly encouraging for future activities. The oil discoveries in the Mackenzie Delta in 1971 and on Ellesmere Island in 1972 are particularly noteworthy as they dispelled the fears that these areas might be gas-prone. These exploratory successes have sparked a revival of interest in the Arctic islands for the major oil companies. Their increasing participation should help to shorten the time required to establish a reserve base of sufficient magnitude to justify development of reserves and construction of the expensive infrastructure that will be required to move these reserves to market. The solution to problems in transporting oil and gas out of Arctic regions continued to be sought in 1971 and the exploratory successes recorded in 1972 no doubt will prompt the research organizations to quicken their efforts.

The discovery of oil and gas on Sable Island, 100 miles off the east coast of Nova Scotia, takes on special significance because it is the first real evidence of the possible presence of commercial quantities of hydrocarbons on the Scotian Shelf. The one discouraging element in the industry is the fact that not enough reserves are currently being found in the western Canadian sedimentary basin to keep up with the rising demand. Discoveries in the interior plains are still being made but at a rate which is becoming increasingly inadequate. Despite the spectacular successes in the Mackenzie Delta and Arctic islands, tremendous financial and physical resources will be required, not only for exploration and development but also for methods to transport the oil to markets efficiently and safely.

Early in 1972 OPEC began another round of negotiations with the international oil companies to obtain 20 per cent participation in those operations which are being conducted by the oil companies within member-states' boundaries. Although this action is being strongly resisted by the oil companies, it seems likely that it is only a question of time until OPEC's demands are accepted. The immediate effect of OPEC's actions on the Canadian oil industry is to increase pressures for the upward pricing of Canadian crude oil. In the longer term, increasing participation by OPEC countries in the development of their petroleum resources will probably increase the amount of available capital required for a more rapid development of Canada's potential frontier reserves. Similar logic will also apply to expanded programs of development of the Athabasca bituminous sands.

Phosphate

W.E. KOEPKE

Phosphate rock is not produced commercially in Canada but large quantities are imported, mostly from the United States, for use in the manufacture of agricultural and industrial phosphate products sold in domestic and export markets. United States and Britain provide the largest export markets for the finished products, principally phosphorus and phosphate fertilizers.

About four fifths of the world's phosphate rock consumption is for agricultural purposes, largely to fertilize soils deficient in phosphorus. World demand for phosphate rock expanded at unprecedented rates from 1963 to 1967 to meet the needs of a rapidly developing phosphate fertilizer industry, but eased subsequently. In Canada, a weakening of farm income in the Prairie Provinces, resulting from difficulties in selling wheat, led to a sharp decrease in the use of phosphate fertilizers in that area from 1968 to 1970. In eastern Canada, fertilizer consumption has continued to increase but at a slower rate and from 1968 to 1971, the industry suffered from chronic oversupply and all plants operated at less than capacity.

Phosphate rock

Phosphate is a term applied to a rock, mineral, or salt containing one or more phosphorus compounds. Phosphate rock, or more correctly phosphorite, is a rock that 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 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 using one of 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 – 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. There are numerous occurrences of low-grade phosphate rock in Canada. They are of limited extent and fall into three main categories, as follows: apatite deposits within Precambrian metamorphic rocks in eastern Ontario and southwestern Quebec; apatite deposits in some carbonate-alkaline complexes in Ontario and Quebec; and sedimentary phosphate rock deposits of late Paleozoic-early Mesozoic age 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. Among the more important alkaline-complex apatite occurrences are: the Nemegos deposits, some 150 miles northwest of Sudbury; the Oka deposit, 20 miles west of Montreal; and some deposits north of Arvida.

Table 1. Canada, phosphate rock imports and consumption, 1970-71

	1970		1971	
	(short tons)	($)	(short tons)	($)
Imports				
United States	2,457,854	14,433,000	2,839,070	16,835,000
Netherlands Antilles	7,492	376,000	5,383	283,000
Britain	4,704	61,000	–	–
Total	2,470,050	14,870,000	2,844,453	17,118,000
	1969		1970	
Consumption[1] (available data)				
Fertilizers, stock and poultry feed	1,590,892		1,663,773	
Chemicals	225,751		225,522	
Other[2]	5,426		7,389	
Total	1,822,069		1,896,684	

Source: Statistics Canada.
[1] Breakdown by Mineral Resources Branch. [2] Includes amounts for refractories, food processing, medicinals and pharmaceuticals.
– Nil.

Table 2. Canada, phosphate rock imports and consumption, 1962-71

	Imports	Consumption
	(short tons)	
1962	1,155,966	1,116,607
1963	1,297,427	1,166,573
1964	1,406,424	1,448,571
1965	1,695,296	1,606,915
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	..

Source: Statistics Canada.
.. Not available.

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, which involves the smelting of phosphate rock with carbon (coke) and a siliceous flux. Coproducts of the process are ferrophosphorus, carbon monoxide and calcium silicate slag. About 9 tons of phosphate rock grading 66-68 per cent BPL are required to manufacture 1 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.

Table 3. World production of phosphate rock, 1969-71

	1969	1970	1971[e]
	('000 metric tons)		
United States	34,223	35,143	34,473
U.S.S.R.[1]	16,290	17,950	..
Morocco	10,665	11,399	11,340
Tunisia	2,600	3,024	2,722
Naura Island	2,193	2,114	..
People's Republic of China	1,400	1,700	..
Togo	1,473	1,508	1,506
South Africa	1,246	1,247	..
Senegal	1,201	1,128	1,134
Christmas Island	1,150	1,072	..
Jordan	1,087	891	..
Israel	990	880	..
Egypt	479	537	..
Ocean Island	565	506	..
Other countries	1,490	1,995	32,204
Total	77,052	81,094	83,379

Source: The British Sulphur Corporation Ltd., Statistical Supplement Nov./Dec. 1971 for 1969-70; U.S. Bureau of Mines Commodity Data Summaries, Jan. 1972 for 1971.
[1] Includes other east European countries.
[e] Estimates; .. Not available.

Table 4. Canada, phosphorus and phosphate fertilizer plants, 1971

Company	Plant Location	Annual Capacity	Principal End Products	Basis for H_2SO_4 Supply for Fertilizer Plants
		(st)		
Elemental phosphorus				
Electric Reduction Company of Canada, Ltd.	Varennes, Que.	20,000	el ph	
	Long Harbour, Nfld.	80,000	el ph	
Total, elemental phosphorus		100,000		
Phosphate fertilizer		(P_2O_5 eq.)		
Belledune Fertilizer Limited	Belledune, N.B.	125,000	am ph	SO_2 smelter gas
Canadian Industries Limited	Beloeil, Que.	28,000	s s	sulphur
	Hamilton, Ont.[1]	28,000	s s	sulphur
	Courtright, Ont.	80,000	am ph	SO_2 pyrrhotite, Copper Cliff
Cominco Ltd.	Kimberley, B.C.	128,000	am ph	SO_2 smelter gas
	Trail, B.C.	86,000	am ph	SO_2 smelter gas
Electric Reduction Company of Canada, Ltd.	Port Maitland, Ont.	190,000	H_3PO_4, ss, t s, ca ph	SO_2 smelter gas and sulphur[2]
Green Valley Fertilizer & Chemical Co. Ltd.	North Surrey, B.C.	1,000	s s	SO_2 smelter gas, Trail
Imperial Oil Limited	Redwater, Alta.	140,000	am ph	sulphur
Northwest Nitro-Chemicals Ltd.	Medicine Hat, Alta.	60,000	am ph	sulphur
St. Lawrence Fertilizers Ltd.	Valleyfield, Que.	56,000	t s, am ph	SO_2 smelter gas
Sherritt Gordon Mines, Limited	Fort Saskatchewan, Alta.	45,000	am ph	sulphur
Simplot Chemical Company Ltd.	Brandon, Man.	..	am ph	
Western Co-operative Fertilizers Limited	Calgary, Alta.	65,000	am ph	sulphur
Total, phosphate fertilizer		1,032,000		

el ph Elemental phosphorus; P_2O_5 eq. Phosphorus pentoxide equivalent; am ph Ammonium phosphates; s s Single superphosphate; t s Triple superphosphate; ca ph Food supplement calcium phosphate. .. Not applicable, H_3PO_4 is made elsewhere.
[1]CIL's Hamilton works were to be closed early in 1972. [2]The smelter supplying SO_2 was closed early in 1971.

Phosphate fertilizers. Phosphate fertilizers are normally produced by decomposing phosphate rock with a strong mineral acid. In Canada, only the two most common acidulants, 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 co-product of the reaction, calcium sulphate, remains in the mixture. Normal raw material requirements to produce 1 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. Off-stream 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 1 ton of 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 of 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), 11-40-0 and 18-46-0. At some plants, phosphoric acid is used to acidulate phosphate rock, in which case the end product is triple superphosphate, normally grading 46 per cent P_2O_5 equivalent.

There are ten phosphoric acid plants in Canada with a combined annual productive capacity of 940,000 tons of P_2O_5 equivalent (see Table 4). The balance of Canada's P_2O_5 productive capacity, amounting to 92,000 tons annually, consists of plants that are capable of producing both single and triple superphosphate.

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 in the neighbouring country. Under foreign aid programs, shipments are occasionally made to southeast Asian countries.

Production statistics for the fertilizer year ended June 30, 1971, are not available at the time of writing; output is, however, believed to have remained relatively unchanged from the previous year with higher demand in both domestic and foreign markets being met from inventories carried over from the previous year. Although domestic consumption in the fertilizer year 1970-71, at 359,781 tons P_2O_5 equivalent, was 16 per cent higher than the previous year, it remained well below the peak of 538,796 tons recorded in 1967-68; most of the 1970-71 gain was in western Canada sales. Similarly, although export figures are not yet available, foreign sales for the fertilizer year 1970-71 are believed to have increased to an all-time high.

A comparison of Tables 4 and 5 in this and past yearbooks reveals that Canada's phosphate fertilizer

Table 5. Canada, phosphate fertilizer production, years ended June 30, 1962-71

	(short tons P_2O_5 equivalent)
1962	261,033
1963	299,453
1964	353,547
1965	374,159
1966	461,608
1967	533,460
1968	538,796
1969	523,934
1970	496,380
1971	. .

Source: Statistics Canada.
. . Not available.

Table 6. Canada, trade in selected phosphate products, 1970-71

	1970		1971	
	(short tons)	($)	(short tons)	($)
Imports				
Calcium phosphate				
United States	20,943	2,093,000	21,978	2,335,000
Belgium and Luxembourg	1,085	54,000	359	20,000
Japan	1,455	89,000	308	17,000
Total	23,483	2,236,000	22,645	2,372,000
Fertilizers				
Normal superphosphate, 22% P_2O_5 or less				
United States	4,983	100,000	356	11,000
Triple superphosphate, over 22% P_2O_5				
United States	62,027	2,571,000	52,546	2,156,000
Phosphatic fertilizer, nes[1]				
United States	58,483	3,846,295	50,174	3,060,000
Britain	120	30,311	137	47,000
France	–	–	23	2,000
Total	58,603	3,876,606	50,334	3,109,000
Chemicals				
Potassium phosphates				
United States	1,859	592,000	2,084	608,000
France	40	14,000	61	22,000
Total	1,899	606,000	2,145	630,000

Table 6 (cont'd)

	1970		1971	
	(short tons)	($)	(short tons)	($)
Imports (cont'd)				
Sodium phosphate, tribasic				
United States	591	92,000	815	120,000
France	55	4,000	225	26,000
Belgium and Luxembourg	–	–	39	4,000
Total	646	96,000	1,079	150,000
Sodium phosphates, nes				
United States	5,857	1,331,000	4,888	1,208,000
West Germany	79	19,000	50	12,000
Total	5,936	1,350,000	4,938	1,220,000
Exports				
Nitrogen phosphate fertilizers				
United States	558,830	35,862,000	599,939	36,322,000
India	13,296	577,000	75,105	4,205,000
Pakistan	10,301	650,000	13,306	907,000
Italy	–	–	12,125	708,000
France	3,351	208,000	3,498	217,000
Britain	–	–	2,316	144,000
Other countries	18,052	969,000	–	–
Total	603,830	38,266,000	706,289	42,503,000

Source: Statistics Canada.
– Nil; nes Not elsewhere specified.
[1] Phosphatic fertilizer, nes became a separate import item beginning in 1969 with imports for that year amounting to 34,856 tons valued at $2,371,729; nearly all was from the United States.

Table 7. Canada, phosphate fertilizer consumption and trade, years ended June 30, 1962-71

	Consumption	Imports[1]	Exports
	(short tons P_2O_5 equivalent)		
1962	196,763	47,035	111,182
1963	223,314	44,443	101,890
1964	264,245	86,279	102,842
1965	293,758	66,604	97,207
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[r]
1970	309,400[r]	11,293	218,501[r]
1971	359,781	18,424	..

Source: Statistics Canada.
[1] Excludes nutrient content of mixtures and of orthophosphoric acid.
.. Not available; [r] Revised figures.

industry has suffered from severe excess capacity during the past three years. Phosphate fertilizer sales in the Prairie Provinces had increased at an average annual rate of 23 per cent from 1959-60 to 1967-68 and producers responded to soaring demands with some firms expanding their operations and others entering the industry. Sales in western Canada fell sharply in 1968-69 and 1969-70 and the resulting oversupply led to substantial price deterioration; in 1970, the price index for fertilizer materials fell to its lowest level in 20 years and most fertilizer manufacturers suffered financial losses.

Outlook. The outlook for Canada's phosphate fertilizer industry is for gradual improvement. Economic trends indicate that farm incomes are rising significantly and, because farmers are fully aware of the role of fertilizers in boosting crop yields, demand for phosphate fertilizer can be expected to increase. However, it is unlikely that market growth rates will repeat the pattern of the 1960's and the implications are that, although it may take several years for sales to approach installed productive capacity, phosphate fertilizer producers can look forward to modest financial gains.

Prices and tariffs

Phosphate rock prices are based upon the BPL content. Maximum limits of moisture, iron and alumina are specified and bonuses are paid and penalties assessed for variations above and below the base grade. Although much phosphate rock is supplied on a contract basis, price quotations serve as a reliable guide. Prices for phosphate fertilizers are usually based on the unit content or minimum analysis of the P_2O_5 equivalent, commonly expressed as an available phosphoric acid (apa).

The December 27, 1971, issue of *Oil, Paint and Drug Reporter* listed the following prices (a unit-ton is 2,000 pounds of 1 per cent of the basic constituent or other standard of the material. The percentage figure of the basic constituent multiplied by the price shown in OPD gives the price of 2,000 pounds of the material).

	($)
Phosphate rock, Florida land pebble, run-of-mine, unground, bulk, carlots, fob mines, per short ton	
(% BPL)	
66-68	6.50
68-70	5.84-7.50
70-72	6.50-8.15
74-75	7.55-9.20
76-77	10.20
Defluorinated phosphate, feed grade, 100-lb bags, carlots, fob Coronet, Fla., freight equalized, 19 per cent P, per short ton	72.25
Phosphoric acid, agricultural grade, fob works, per unit-ton, 52-54 per cent apa	1.00-1.05
Superphosphate, run-of-pile, pulverized, bulk, carlots, fob works, per unit-ton, under 22 per cent apa	.80-.95

The price listings remained essentially unchanged from the previous three years.

Phosphate rock and phosphate fertilizer materials enter Canada and the United States duty free.

Platinum Metals

C. J. CAJKA

The platinum group metals, also referred to as the platinoids, consist of platinum, palladium, rhodium, iridium, ruthenium and osmium. The U.S.S.R., Republic of South Africa and Canada, ranked in decreasing order of production volume, are the major producers of platinoids. The United States, Colombia. Japan and Ethiopia have a small output.

Platinoids are found in nature associated with basic and ultrabasic rocks and in placer deposits. A large quantity of platinum metals is recovered as a byproduct of nickel-copper refining, but a major portion of world production comes from mines worked principally for platinoids, notably in South Africa.

Most producers increased capacity very rapidly during the 1960's. South African producers expanded their facilities because of a short supply during the sixties and an anticipated growth in demand in the seventies. Canadian capacity increased because platinoids are a byproduct of nickel-copper refining and Canadian nickel-copper processing facilities have undergone major expansion during the past few years.

During 1970 the platinum metals came into plentiful supply. Furthermore, anticipated growth in demand has not materialized, primarily because the automobile industry still remains uncommitted to using platinum-based exhaust systems for new automobiles. The latter application was expected to be a major new market for platinum. As a result of increased production capacity and a slow growth in demand, there was in 1971, continuing into 1972, excess capacity in the industry.

Canadian production of platinum metals in 1971 was 468,000 troy ounces valued at $38,928,000, a decrease from 482,428 troy ounces valued at $43,556,597 in 1970. Output declined mainly because The International Nickel Company of Canada, Limited (INCO) reduced nickel-copper ore production, the source of Canadian platinum metals, to ease the nickel oversupply situation in world markets.

World platinum metals production in 1971 is estimated at 4.017 million troy ounces, a decrease of 5.2 per cent from 1970. The U.S.S.R. accounted for 2.3 million ounces, Republic of South Africa for 1.2 million ounces, Colombia for 25,000 ounces and the United States for 15,000 ounces. During the year, the two largest noncommunist world platinum producers, Rustenburg Platinum Mines Limited and Impala Platinum Limited, both of South Africa, announced that they were planning major production curtailments for 1972.

Production

Canada. Canadian nickel-copper sulphide ores, principally those of the Sudbury area of Ontario and the Thompson-Wabowden area of Manitoba, contained most of the platinum metals recovered in Canada. It has been estimated that the Sudbury ores contain about 0.025 troy ounces of platinoids per ton, but there is some indication that the lower-grade nickel ores presently being mined contain less platinum group metals. The platinoids are collected in a nickel-copper alloy and sulphide matte from the smelting process. INCO's nickel-copper anodes are subjected to electrolysis and the precious metals are collected from the electrolytic tanks as sludge. This sludge is purified, then shipped to INCO's Acton refinery in Britain. Osmium is refined at INCO's Port Colborne, Ontario, nickel refinery. Falconbridge Nickel Mines Limited ships nickel-copper matte to its refinery in Kristiansand, Norway. Platinoid-bearing sludge from the latter plant is sent to Engelhard Minerals & Chemicals Corporation at Newark, New Jersey, for further refining.

Table 1. Canada, platinum metals production, 1970-71

	1970		1971p	
	(troy ounces)	($)	(troy ounces)	($)
Production[1]				
Platinum, palladium, rhodium, ruthenium, iridium	482,428	43,556,597	468,000	38,928,000
Exports				
Platinum metals in ores and concentrates				
Britain	622,661	40,545,000	201,478	21,938,000
Norway	15,843	1,485,000	12,003	1,153,000
Total	638,504	42,030,000	213,481	23,091,000
Platinum metals				
United States	6,887	524,000	7,043	464,000
Britain	1,951	237,000	3,638	336,000
Mexico	–	–	605	22,000
Jamaica	21	4,000	29	4,000
Other countries	2,703	379,000	–	–
Total	11,562	1,144,000	11,315	826,000
Platinum metals in scrap				
Britain	12,980	1,417,000	13,722	1,384,000
United States	17,282	1,311,000	13,602	1,160,000
Total	30,262	2,728,000	27,324	2,544,000
Re-exports[2]				
Platinum metals, refined and semiprocessed	20,399	2,365,735	35,523	3,185,000
Imports				
Platinum lumps, ingots, powder and sponge				
Britain	3,254	451,000	7,016	887,000
United States	50	9,000	1,048	127,000
Total	3,304	460,000	8,064	1,014,000
Other platinum group metals in lumps, ingots, powder and sponge				
Britain	30,654	1,612,000	33,051	1,804,000
South Africa	13,423	514,000	11,727	431,000
United States	13,364	537,000	766	49,000
Total	57,441	2,663,000	45,544	2,284,000
Total platinum and platinum group metals				
Britain	33,908	2,063,000	40,067	2,691,000
United States	13,414	546,000	1,814	176,000
South Africa	13,423	514,000	11,727	431,000
Total	60,745	3,123,000	53,608	3,298,000
Platinum crucibles				
United States	15,232	1,863,000	22,195	3,531,000
Britain	5	1,000	53	7,000
Total	15,237	1,864,000	22,248	3,538,000
Platinum metals, fabricated materials, not elsewhere specified				
Britain	15,819	2,247,000	14,397	1,862,000
United States	3,187	189,000	5,030	291,000
Total	19,006	2,436,000	19,427	2,153,000

Source: Statistics Canada.
[1] Platinum metals, 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.
p Preliminary; – Nil.

Table 2. Canada, platinum metals production and trade, 1962-71

	Production[1]	Exports		Imports
		Domestic[2]	Re-exports[3]	
	(troy oz.)	($)	($)	($)
1962	470,787	24,340,175	8,644,781	12,925,466
1963	357,651	24,555,816	10,144,484	13,590,575
1964	376,238	20,812,514	20,888,749	17,369,291
1965	463,127	30,103,254	11,389,395	13,461,546
1966	396,059	25,800,000	11,779,822	14,930,000
1967	401,263	29,829,000	9,087,955	13,161,000
1968	485,891	38,068,000	8,254,753	17,077,000
1969	310,404	35,306,000	5,247,240	9,300,000
1970	482,428	43,174,000	2,365,735	3,123,000
1971p	468,000	23,917,000	3,185,000	3,298,000

Source: Statistics Canada.
[1]Platinum metals, content of residues, concentrates and matte shipped to Britain and Norway for treatment. [2]Value of platinum metals and platinum concentrates exported for treatment. [3]Re-exports of platinum metals, refined and semiprocessed, imported and re-exported after undergoing no change or alteration. [4]Imports, mainly from Britain, of refined and semiprocessed platinum metals, derived from Canadian concentrates and residues, most of which is re-exported.
pPreliminary.

In addition to production from Ontario and Manitoba, nickel-copper ores are mined in Quebec and British Columbia. A bulk nickel-copper concentrate, made from British Columbia ore, contains only very minor amounts of the platinum metals which are not reported in production statistics.

In the Sudbury area of Ontario, The International Nickel Company of Canada, Limited operated 14 nickel-copper mines, four mills and two smelters, and is constructing a nickel refinery, where a platinoid-bearing residue will be recovered. The new 35,000-ton-a-day Clarabelle concentrator was completed at year-end. INCO is preparing two new mines for production, one in the Sudbury area for operation in 1975 and the other at Shebandowan, Ontario, for 1972. The company owns a nickel refinery at Port Colborne.

During 1971 world demand for nickel became far more depressed than had been anticipated by producers, with the result that producers' inventories accumulated to an undesirable level. INCO reacted to the unfavourable nickel market by announcing production cutbacks which will reduce nickel output about 30 per cent by February of 1972. In the Sudbury area, Murray mine and Clarabelle No. 2 open pit were closed and production was reduced at Stobie mine. In addition, operations are to be suspended at Creighton No. 3 shaft, Crean Hill mine, Coniston smelter, and the Creighton mill in early 1972. These closures and cutbacks, along with those in the Thompson area of Manitoba, resulted in a decline in Canadian platinum metals production in 1971. Similar major production reductions were not announced by other Canadian nickel-copper producers although Falconbridge is planning to reduce nickel output by 5 per cent in 1972.

Falconbridge Nickel Mines Limited operated eight nickel-copper mines, four mills and one smelter, and was developing two more mines and a mill for production in the Sudbury region. Production from the new nickel-iron refinery at Falconbridge was initiated during the year.

Two other nickel-copper producers operated mines in Ontario during 1971. Consolidated Canadian Faraday Limited continued to ship nickel-copper concentrate from its Gordon Lake mine to The International Nickel Company of Canada, Limited (INCO) at Sudbury. Texmont Mines Limited began production at 500 tpd in the Timmins area. The Langmuir mine, a joint Noranda Mines Limited-INCO project near Timmins, is scheduled for production in 1972.

In Quebec, Renzy Mines Limited continued production from its mine and mill in Hainault Township. Concentrate was shipped to Falconbridge for smelting. Completion of the new nickel-copper-cobalt refinery, to be built by Falconbridge at Becancour, has been delayed to 1976 because of sluggish nickel markets.

Three companies mine nickel-copper ores in Manitoba. INCO operated four mines and a smelter-refinery complex in the Thompson region. In conjunction with 1971 production curtailments, INCO closed Soab mine and Pipe No. 1 shaft, and reduced production at the Pipe open pit. Production in 1972 also will be reduced at the Birchtree mine. Falconbridge placed its 1,000 tpd Manibridge mine and mill into production in 1971. Manibridge concentrate is shipped to Falconbridge for smelting. Dumbarton Mines Limited, located in the Bird River area of Manitoba, shipped ore to the Consolidated Canadian Faraday mill for concentration, and the concentrate, in turn, was shipped to the Falconbridge smelter.

Giant Mascot Mines Limited, located near Hope, British Columbia, resumed production of nickel-copper concentrate after rebuilding all surface buildings which had been destroyed in a fire in 1970. Giant Mascot ships its concentrate to Japan for nickel and copper recovery. Hudson Bay Mining and Smelting Co., Limited is preparing the Wellgreen mine, near Kluane Lake in the Yukon Territory, for production in mid-1972. Concentrate from this operation will be shipped to Japan for further processing.

U.S.S.R. Platinoids in the U.S.S.R. are derived mainly from nickel deposits in basic and ultrabasic rocks of the Norilsk region of Siberia and the Kola Peninsula of northwest Russia. Also, small amounts of platinum are recovered from placer deposits in the southern Urals. Russian production in 1971 is estimated at 2.3 million ounces, an increase from 2.2 million ounces estimated for 1970.

South Africa. Producers in the Republic of South Africa, the noncommunist world's largest supplier of platinum metals, have been involved in major expansion programs for the past few years. More recently, some scheduled projects have been delayed because of current oversupply in the industry. Most capacity and production data given below refer to platinum only. It is useful to recall that South African ores contain approximately 2 troy ounces of palladium for every 5 ounces of platinum.

The noncommunist world's largest platinum producer, Rustenburg Platinum Mines Limited, operates three mines, a smelter and a refinery in the Transvaal district. Rustenburg recently increased capacity to 1.1 million ounces of platinum a year but reduced production by 20-30 per cent of capacity early in 1971 and to less than 50 per cent late in the year. Former plans to increase capacity to 1.3 million ounces by mid-1972 were shelved in late 1970.

Impala Platinum Limited, owned by Union Corporation Limited, Industrial Selections Ltd., International Nickel, U.C. Investments Ltd., Marula Platinum (Pty) Ltd., National Selections Ltd., and Hambros Bank Ltd., operates a mine-mill-refinery complex near Rustenburg. Capacity at the operation is 300,000 ounces of platinum a year and can be easily expanded to 350,000 ounces when demand conditions warrant such action. The company is currently producing platinum at a rate of about 200,000 ounces a year. Western Platinum Limited, a Lonrho Limited-Falconbridge-Superior Oil Company joint venture in the Rustenburg region, commenced production at its Middlekraal mine and mill in 1971. The mine produced 305,000 tons of ore in 1971. Production from the smelter began in December of 1971. Matte, which contains copper, nickel and platinoids, is to be shipped to Falconbridge's refinery in Norway, and platinum metals bearing residues from nickel-copper refining will be flown back to South Africa for further processing. Western Platinum hopes to achieve a production rate of 150,000 ounces of platinoids by mid-1972 and expects to have refined metal available for markets in the third quarter of the year. If previously announced expansion plans are carried out, Western Platinum will increase capacity to 430,000 ounces of platinum group metals by 1974-75. Construction of a platinum refinery near the mine is under consideration. Atok Investments (Pty) Limited, a subsidiary of Anglo-Transvaal Consolidated Investment Company Limited, produces platiniferous concentrate from a mine and mill about 40 miles east of Pieterburg. Capacity at Atok's installation is reported to be about 15,000 ounces of platinoids a year.

United States. Mine production of the platinoids in the United States was from placer deposits in the Goodnews Bay area of Alaska. Some primary production was obtained as a byproduct of gold and copper refining.

Colombia. Production in Colombia, amounting to about 25,000 ounces in 1971, was obtained from placers in the Choco district.

Others. During 1971, interesting discoveries of platinoid mineralization were reported in Australia, New Zealand and Greenland. None of these have been assessed with respect to commercial development.

Uses

Platinoids have several applications in industry because of their many special properties, the principal ones being catalytic activity, resistance to corrosion, resistance to oxidation at elevated temperatures, high melting point, high strength and good ductility. Platinum and palladium are the major platinum metals; iridium, osmium, ruthenium and rhodium are used mainly as alloying elements to modify properties of platinum and palladium. Rhodium is also used in plating.

The catalytic action of platinum, palladium, rhodium and ruthenium is utilized in the petroleum industry for the production of high octane gasolines; in the chemical industry for the production of sulphuric and nitric acids, and the hydrogenation of organic chemicals; and in the drug industry for the manufacture of pharmaceuticals, vitamins and antibiotics. A recent development is the use of platinum metal salt and complexes as homogeneous catalysts for the oxidation, isomerization, hydrogenation and polymerization of olefins. Platinum is used on a limited scale in emission control systems where clean exhausts are absolutely essential. A very large market will develop if the use of platinum in automobile exhaust systems becomes widely accepted.

The corrosion resistance of the platinum metals is utilized in laboratory utensils to contain corrosive liquids and as protective coatings for vessels used in the melting of materials for laser crystals. Wear resistance of the platinum metals makes them ideal for use as spinnerets in the production of glass, rayon and other synthetic fibres. Platinum and platinum alloys are used for the cathodic protection of ships' hulls and as inert anodes in electro-deposition. Palladium is used as contacts in automatic electric switching gear and in dentistry. Wear resistance and beauty of finish are the qualities that create a demand for the platinum metals in the manufacture of high-quality jewelry.

Iridium is used mainly as a hardening additive in platinum and palladium alloys for use in the jewelry industry, in electrical contacts and components for chemical manufacture, and in high-purity iridium crucibles for growing laser crystals and synthetic gemstones. More recently, it was reported that a new use had been found for iridium as a catalyst for petroleum refining.

The principal uses of osmium are in chemical, dental and medical applications. Rhodium is used mainly in jewelry and chemical applications and ruthenium finds its principal use in the chemical industry.

Outlook

In the short term, the outlook for platinum continues to be oversupply and substantial excess capacity. Total potential noncommunist world supply of primary metal, including approximately 300,000 ounces shipped from the U.S.S.R., amounts to about 2.0 million ounces a year and, on short notice, can be increased to 2.4 million ounces. On the other hand, production has been reduced and will probably not exceed 1.3 million ounces in 1972, again including shipments of 300,000 ounces from the U.S.S.R. Producers' inventories are reported to be very high. Although consumption of platinum varies widely, it is estimated that the noncommunist world will require about 1.5 million ounces a year in the immediate future. Canadian production of platinum metals cannot be easily adjusted to demand because the platinoids are a byproduct of nickel-copper refining. However, the South African producers can adjust (and are adjusting) output to demand and are expected to maintain considerable excess capacity in the short term.

The medium term is extremely clouded because of factors hinging upon pollution issues. First, widespread acceptance of platinum emission control systems for automobiles would create a very large market but, to date, only the Ford Motor Company has announced it intends to use the platinum system and this is only for 1974 California vehicles and one half of its 1975 vehicles. U.S. automobile manufacturers must meet strict standards for 1975 automobile exhaust emissions in accordance with the Clean Air Act of 1970. However, there may be less expensive substitutes for platinum systems. In view of the unsettled state of emission control technology, the potential market in automobile exhaust converters could vanish abruptly.

Second, there is constant pressure to remove lead from engine fuels, partly because lead emissions are generally classified as pollutants but also because lead renders platinum ineffective in the new platinum emission control devices. One alternative to lead is upgrading engine fuels to an acceptable octane level by additional refining. A major growth in catalytic refining under normal circumstances, would create a large market for platinum catalysts but the recent application of more efficient platinum-rhenium catalysts has drastically reduced platinum requirements per unit volume of petroleum product and the new catalysts have a much longer life. The situation is further clouded by the possibility of automobile manufacturers developing a new generation of low-compression engines which would make high octane fuels unnecessary in automobiles of the future.

With cutbacks in platinum production, the supply of other associated platinum metals has also been reduced. The demand for palladium is expected to show moderate growth but adequate supplies from the U.S.S.R. appear to be available. Supply and demand for rhodium and osmium are approximately in balance and no shortage is expected for these metals in the near future.

Table 3. World production of platinum group metals

	1969	1970	1971[e]
	(troy oz)	(troy oz)	(troy oz)
U.S.S.R.	2,100,000	2,200,000	2,300,000
Republic of South Africa	964,000	1,502,000	1,200,000
Canada	310,404	482,428	468,000
Colombia	27,805	26,000	25,000
United States	21,586	17,000	15,000
Other countries	7,360	8,000	9,000
Total	3,431,155	4,235,428	4,017,000

Sources: U.S. Bureau of Mines, *Minerals Yearbook, 1969;* U.S. Bureau of Mines, Commodity Data Summaries, January 1972, for 1970 and 1971.
[e]Estimate.

Prices

The price of platinum weakened slightly during the year and reflected the general oversupply condition for this metal. Producers quoted a price of $120-135 an ounce at the beginning of the year but lowered the price to $120-125 by year-end. At the same time, the dealers' price fell to the $105-119 range. Producers' prices of other platinoids remained relatively constant throughout the year. There was some downward pressure on the prices of iridium, osmium, palladium and ruthenium as dealers' prices were generally quoted below producers' prices. Price changes for the platinoids are listed below. It should be noted that the producers' price is that quoted by Engelhard Minerals & Chemicals Corporation and Johnson, Matthey & Co., Limited, while the dealers' price is a free market price quoted by merchant dealers and agents selling for the U.S.S.R.

	Producers	Dealers
	(U.S. $ per troy ounce)	
Iridium		
Jan 1-Dec. 31	150-155	145-148
Osmium		
Jan. 1-July 31	200-225	200-225
Aug. 1-Dec. 31	200-225	175-200
Palladium		
Jan. 1-May 2	36-38	35-35.50
May 3-Oct. 31	37-39	35.25-35.75
Nov. 1-Dec. 31	36-38	34.50-35
Platinum		
Jan. 1-Jan. 20	130-135	120-125
Jan. 21-Feb. 21	120-135	105-115
Feb. 22-Dec. 31	120-125	105-119
Rhodium		
Jan. 1-Jan. 10	205-210	202-205
Jan. 11-June 30	200-205	198-200
July 1-Dec. 31	195-200	195-198
Ruthenium		
Jan. 1-Dec. 31	50-55	45

Source: *Metals Week.*

Tariffs

Canada

Item No.		British Preferential	Most Favoured Nation	General
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
48900-1	Crucibles of platinum, rhodium and iridium and covers therefor	free	free	15%

United States

Item No.				
601.39	Precious metal ores	free		
605.02	Platinum metals, unwrought, not less than 90% platinum	free		
		On and After Jan. 1, 1970	On and After Jan. 1, 1971	On and After Jan. 1, 1972
		(%)	(%)	(%)
605.03	Other platinum metals, unwrought	28	24	20
605.05	Alloys of platinum, semimanufactured, gold-plated	35	30	25
605.06	Alloys of platinum, semimanufactured, silver-plated	16.5	14	12
605.08	Other platinum metals, semimanufactured, including alloys of platinum	28	24	20

Sources: The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa. Tariff Schedules of the United States, Annotated (1971) TC Publication 344.

Potash

W.E. KOEPKE

World demand for potash was especially strong in 1971 but for the sixth consecutive year, productive capacity far exceeded market requirements. A relative balance between world demand and actual supply was maintained through the use of production controls, in the form of The Potash Conservation Regulations, on Canada's potash industry in the Province of Saskatchewan. In essence, each mine is granted a basic quota of 40 per cent of rated mine and mill capacity, plus a sales allowable reflecting past sales performance and market requirements. Production licences, covering a period of one year and subject to quarterly revisions, are issued on a quarterly basis; supplementary licences are authorized if required. In addition to the production controls, the potash producers must honour a Ministerial Order specifying a minimum price of not less than thirty-three and three-quarter cents (33.75¢) Canadian per unit of potassium oxide equivalent. The regulations are administered by a three-member potash board.

Many companies entered the potash industry and others expanded their potash producing facilities in the early and mid-1960's in response to soaring world demand and rising prices accompanied by high profit margins. As excess supply became available in 1966, prices began to weaken and the trend continued throughout 1967, 1968 and 1969, when North American prices reached the lowest level on record. In an effort to restore order to the marketing of potash in North America and other parts of the world and to prevent a possible shutdown of any newly opened mines in Saskatchewan, the provincial government introduced the production controls, effective January 1, 1970.

There was some hope that other world producers – U.S.S.R., East Germany, West Germany, France, United States, Spain, Israel and Republic of Congo – would co-operate by moderately restraining output and abstaining from taking advantage of the floor price set by Saskatchewan. Most United States potash producers followed Saskatchewan's leadership by issuing essentially identical price lists (subject to exchange differences) for sales in Canada and the United States for potash produced in either of the two countries. Producers in western Europe also boosted prices in 1970 but maintained an advantage of $3 to $4 a ton over Canadian potash landed in Rotterdam. Except for some high-grade industrial material, Canadian potash exports to Europe all but ceased in early 1970. With regard to foreign production, statistical evidence for 1970-71 reveals that output decreased only in the United States and Spain while Israel and U.S.S.R. recorded the largest absolute increases in their entire history. Exports from U.S.S.R. soared from 698,000 metric tons in 1969 to 1.3 million in 1970.

Marketing conditions improved somewhat for Saskatchewan operators in mid-1971 as supplies tightened in western Europe, partly because the Spanish industry and the Congolese producer failed to achieve output targets. The resulting shortage allowed Canadian potash to re-enter west European markets and shipments to Rotterdam resumed in mid-1971.

Production and developments in Canada

According to the Saskatchewan Department of Mineral Resources, production of potash in the province in 1971 was 3,938,489 tons K_2O equivalent and sales totalled 3,974,843 tons. Production was up from 3,497,901 tons in 1970 and sales were up from 3,354,710 tons, a rise of 12.6 per cent. Statistics Canada figures reveal that shipments increased from 3,420,212 tons K_2O equivalent in 1970 to 3,872,000 tons in 1971. The Department of Mineral Resources sales figures should compare with the Statistics Canada shipment figure but variations arise from differences in compilation. The value of potash sales according to

Table 1. Canada, potash production, shipments and trade, 1970-71

	1970		1971p	
	(short tons)	($)	(short tons)	($)
Production, potassium chloride				
Gross weight[1]	5,721,000	..	6,441,000	..
K_2O equivalent	3,497,901	..	3,938,489	..
Shipments				
K_2O equivalent	3,420,212	108,694,791	3,872,000	128,067,000
Imports, fertilizer potash				
Potassium chloride				
United States	23,421	720,000	62,891	1,801,000
West Germany	2	1,000	12	4,000
Total	23,423	721,000	62,903	1,805,000
Potassium sulphate				
United States	20,447	880,000	14,562	608,000
Potash fertilizer, nes				
United States	27,202	638,000	15,228	386,000
Potash chemicals				
Potassium carbonate	1,094	185,000	2,500	217,000
Potassium hydroxide	1,816	368,000	997	236,000
Potassium nitrate	2,954	364,000	3,193	348,000
Potassium phosphates	1,899	605,000	2,145	630,000
Potassium bitartrate	179	113,000	76	85,000
Potassium silicates	1,031	217,000	974	190,000
Total, potash chemicals	8,973	1,852,000	9,885	1,706,000
Exports, fertilizer potash				
Potassium chloride				
United States	4,237,567	93,302,000	4,311,292	102,704,000
Japan	605,295	14,030,000	645,554	15,416,000
India	141,340	3,313,000	313,880	7,338,000
New Zealand	106,642	2,132,000	119,003	3,012,000
Netherlands	132,568	3,219,000	99,587	2,263,000
Brazil	–	–	73,326	2,230,000
Australia	42,746	874,000	91,278	2,229,000
South Korea	78,933	1,411,000	102,265	2,130,000
Philippines	20,129	420,000	74,515	1,680,000
Belgium-Luxembourg	–	–	76,273	1,659,000
Other countries	108,659	2,604,000	101,684	2,432,000
Total	5,473,879	121,305,000	6,008,657	142,463,000

Sources: Statistics Canada; Saskatchewan Department of Mineral Resources for K_2O production figures.
pPreliminary; – Nil; . . Not applicable.
[1]Based on a conversion factor of $K_2O \times 1.64$ for standard, special standard, granular and coarse grades, and $K_2O \times 1.60$ for soluble and chemical grades.

the Saskatchewan Department of Mineral Resources amounted to $146 million in 1971 compared with $108.7 million worth of shipments in 1970 (Statistics Canada figure).

Producer stocks on hand at the end of 1971 totalled 826,615 tons K_2O equivalent, down from the previous year's alltime high of 959,479 tons.

As a noun the term potash means potassium oxide (K_2O) equivalent and when used as an adjective it refers to potassium compounds or potassium-bearing materials. There are more than 70 potassium-bearing minerals but only a few of the soluble potash salts found in bedded deposits and lake, sea, or subsurface brines, are of economic significance. Other potash

Table 2. Canada, potash production and sales by grade[1] and destination, 1970-71

(short tons of K_2O equivalent)

	1971							1970[r]
	Standard	Special Std.	Coarse	Granular	Soluble	Chemical	Total	
Production	1,093,359	336,727	1,428,924	636,423	366,471	76,585	3,938,489	3,497,901
Sales								
Domestic	29,383	–	132,274	4,243	11,033	273	177,206	192,022
U.S.A.	690,385	20,808	1,202,763	543,410	216,691	74,428	2,748,485	2,459,228
Offshore								
Australia	–	–	7,840	46,414	–	–	54,254	13,700
Belgium	–	–	–	–	–	–	–	5,111
Borneo	–	–	–	–	–	–	–	12
Brazil	5,666	–	24,456	17,405	–	–	47,527	–
Colombia	–	–	–	2,957	–	–	2,957	–
England	–	23,145	–	–	–	1,259	24,404	26,016
France	14,911	55,717	–	6,795	–	–	77,423	–
West Germany	–	4,540	–	–	–	–	4,540	6,669
Holland	–	2,602	–	–	–	–	2,602	7,588
India	133,251	36,521	47	19,846	–	–	189,665	81,649
Indonesia	3,065	1,851	–	–	487	–	5,403	889
Ireland	1,747	505	–	–	–	–	2,252	9,307
Italy	12,907	–	–	–	–	–	12,907	12,692
Japan	54,750	176,938	18,890	–	117,440	–	368,018	351,190
Korea	78,576	–	–	–	–	–	78,576	36,455
Malaysia	10,119	–	–	–	1,831	–	11,950	7,936
New Zealand	59,658	–	–	–	–	–	59,658	61,765
Pakistan	–	–	–	–	–	–	–	15,946
Philippines	31,915	7,872	1,211	–	–	–	40,998	12,527
Singapore	7,238	–	–	–	–	–	7,238	7,181
South Africa	–	–	–	–	–	–	–	1,946
Sweden	–	2,855	–	–	648	–	3,503	7,530
Switzerland	–	704	–	–	–	–	704	2,662
Taiwan	14,744	64	–	–	–	–	14,808	10,145
Vietnam	935	–	–	–	–	–	935	4,340
Subtotal	429,482	313,314	52,444	93,417	120,406	1,259	1,010,322	683,256
Undetermined, via Vancouver	26,808	4,408	3,164	3,083	1,367	–	38,830	29,128
Total sales	1,176,058	338,530	1,390,645	644,153	349,497	75,960	3,974,843	3,363,634

Source: Saskatchewan Department of Mineral Resources, Monthly Potash Report.
[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.
[r]Revised sales figures; – Nil.

sources include wood ashes, kelp, guano and organic matter. Almost 95 per cent of the world's potash production is for fertilizers. Small quantities are used in the manufacture of soaps, glass, ceramics, textiles, dyes, explosives and numerous chemicals.

Potash minerals and compounds are graded in terms of K_2O equivalent. For example, potassium chloride (KCl), which accounts for over 90 per cent of the world's potash fertilizer consumption, has a K_2O equivalent of 63.2 per cent ($KCl \times 0.632 = K_2O$ and conversely, $K_2O \times 1.58 = KCl$). Fertilizer grades produced in Canada normally range from an accepted minimum of 60 per cent up to 63 per cent K_2O equivalent, the average for standard, special standard,

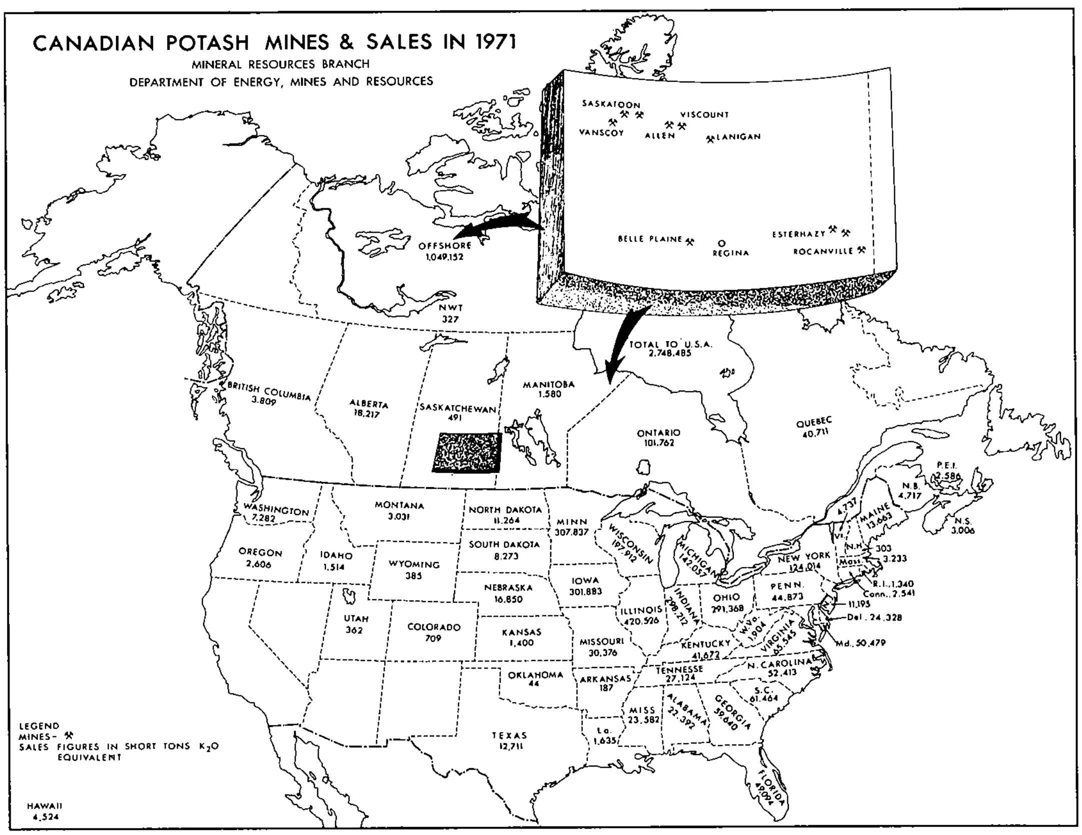
Table 3. Canada, potash production and trade years ended June 30, 1962-71

	Production	Imports[1]	Exports
	(short tons of K_2O equivalent)		
1962	–	124,370	–
1963	403,679	75,180	310,633
1964	747,257	58,115	638,749
1965	1,176,408	49,780	983,556
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	3,219,869	32,017	3,191,666

Source: Statistics Canada – Fertilizer Trade.
[1]Includes potassium chloride, potassium sulphate and sulphate of potash magnesia, except that contained in mixed fertilizers.
– Nil.

granular and coarse being 60.8 per cent, and for soluble and chemical grades, 62.5 per cent. Pure potassium chloride contains 52.4 per cent potassium (K).

Deposits and occurrences. Although underground potash deposits occur in Manitoba, Saskatchewan, Alberta, Newfoundland, Nova Scotia and New Brunswick, only those in Saskatchewan have been exploited commercially. The deposits in Nova Scotia are in the Malagash-Wallace area of Cumberland County; they occur in the Windsor Formation, of Mississippian age, at a depth of nearly 4,000 feet and grade about 5 per cent K_2O equivalent. The Newfoundland deposits also occur in Mississippian rocks and are of low grade. The New Brunswick deposits, discovered early in 1971 in the Sussex area of Kings County, were encountered at a depth of 900 to 1,000 feet; bed thicknesses are as much as 32 feet and grades range from 21 to 25.5 per cent K_2O equivalent. Discovery of these deposits resulted from a joint federal-provincial exploration program conducted in search of salt and headed by the



New Brunswick Department of Natural Resources; the department is expected to issue an exploration permit to a mining company some time in 1972.

The deposits in western Canada underlie a broad northwesterly trending belt that extends across southern Saskatchewan into the bordering areas of Alberta and Manitoba; they occur within the Prairie Evaporite Formation, which constitutes the upper 50 to 700 feet of the Middle Devonian Elk Point Group. Depths of the Saskatchewan deposits range from 3,000 feet at the northern edge of the beds to 7,000 feet near the International Boundary. Individual potash beds reach 20 feet in thickness. Sylvite (KCl) and halite (NaCl) are the predominant minerals and form a physical mixture known as sylvinite, which is the chief 'ore'. In some areas the potash beds contain up to 3 or 4 per cent carnallite ($KCl \cdot MgCl_2 6H_2O$). In other areas where this mineral is generally lacking, the beds have a higher clay content of up to 6 per cent. The deposits in Saskatchewan grade as high as 35 per cent K_2O equivalent. Potash reserves, grading a minimum of 25 per cent K_2O equivalent, are estimated at 50 billion tons.

Mining and processing. Mining is either by underground excavation or by solution extraction. A modified room-and-pillar method is used in underground excavation employing electrically powered continuous mining machines that cut openings ranging from 7 to 10 feet in height and 18 to 22 feet in width. Mining is on one level and working depths from mine to mine range from 3,100 to 3,500 feet. Shuttle cars and/or portable conveyors transfer broken rock to a main conveyor for haulage to the hoisting shaft. Normally there is some underground primary crushing.

In the surface plant, the rock is further crushed and the sylvite is removed by flotation. The sylvite is then dried and screened to provide as many as four 'grades' of potassium chloride (muriate of potash in common terminology): granular, coarse, standard and special standard. Compactors are used to increase the proportion of the more desirable granular and coarse grades. Chemical or soluble grades are also produced from evaporation and crystallization circuits that are fed with dust and fines collected throughout the plant.

For solution mining, a weak brine is pumped into the potash beds at about 5,200 feet through a selected pattern of cased wells. The injected brine dissolves the sylvinite and potash-rich solutions are circulated to surface for refining. Refining involves a sequence of multiple-effect evaporation and crystallization whereby potassium chloride crystals are precipitated, drawn off, dried and screened. Products resulting from evaporation and crystallization processes have a higher degree of purity than floated potash.

Current operations. Although potash permits have been issued in all three Prairie provinces and extensive drilling has been done in the area around St. Lazare, Manitoba, most exploration work has been concentrated in a belt 120 miles wide that extends southeasterly from just west of Saskatoon to the Manitoba border. This area, covering about 21,000 square miles, is designated and identified by the Province of Saskatchewan as Commercial Potash Area No. 1 under the Oil and Gas Conservation Act. Area No. 2 covers a 936-square mile area around Unity, the site of the first attempt to mine potash in Saskatchewan. In December 1971 there were outstanding in Saskatchewan, ten potash leases comprising 816,276 acres, one 99,840-acre lease pending, and eight permits, totalling 693,307 acres.

The conventional shaft mines are concentrated in two regions of Area No. 1: six are in the Saskatoon-Lanigan region, and three are in the Esterhazy-Rocanville region. The solution mine is in the deeper part of the evaporite basin, near Regina; other solution-mining experiments have also been conducted in the Regina region.

As indicated in Table 4, there are 10 potash mines in Saskatchewan with an installed annual productive capacity of 13.68 million tons of potassium chloride (8.32 million tons K_2O equivalent). All mines were in operation throughout 1971, with the exception of Cominco Ltd.'s mine which was flooded in August 1970 and is expected to be reopened by early 1973, and International Minerals & Chemical Corporation (Canada) Limited's K-2 mine which was closed from August 1970 to July 1971 for shaft repairs.

In 1971 Shamrock Chemicals Limited began constructing a 240-ton-a-day potassium sulphate plant at Port Stanley, Ontario, bordering on Lake Erie. Trial production runs commenced early in 1972 and full production was scheduled for late 1972. The manufacturing process involves reaction of spent sulphuric acid from oil refineries with potassium chloride. Heretofore, all Canada's potassium sulphate needs have been imported.

Consumption and trade. Canadian potash consumption is about 8 per cent of its output, the principal consuming areas being the farm communities of southern Ontario, Quebec and the Maritime Provinces. Domestic sales of Saskatchewan potash were 177,206 tons K_2O equivalent in 1971, down from the previous year's level of 192,022 tons. The Potash Institute of North America reported that total deliveries of potash salts for agricultural purposes in Canada in 1971 were 226,346 tons K_2O equivalent, up 10.4 per cent from 1970. The lower level of Saskatchewan sales in the domestic market is attributed to imports, the quantity of potassium chloride from United States rising from 11,184 tons in 1969, to 23,421 tons in 1970, and to 62,891 tons in 1971. Most of the imports entered areas of the Maritime Provinces that had previously been served

Table 4. Canada, summary of potash mines and their production allowables for 1971

Company	Location[1]	Initial Production	Production Capacity KCl	Production Capacity K_2O eq.	Production Allowable	Operating Rate (allowable as % of capacity)
			(st yearly)		(st K_2O eq.)	
International Minerals & Chemical Corporation (Canada) Limited	K-1, Esterhazy	1962	2,100,000	1,280,000	1,050,473	45.1
	K-2, Esterhazy[2]	1967	1,720,000	1,050,000		
Kalium Chemicals Limited	Belle Plaine	1964	1,500,000	937,500	401,973	42.9
Potash Company of America	Saskatoon	1965	760,000	460,000	219,882	47.8
APM Operators Ltd.	Allan	1968	1,500,000	912,700	404,099	44.2
Alwinsal Potash of Canada Limited	Lanigan	1968	1,000,000	600,000	240,000	40.0
Duval Corporation of Canada	Saskatoon	1968	1,200,000	732,000	310,110	42.4
Cominco Ltd.[3]	Vanscoy	1969	1,200,000	720,000	264,356	36.7
Central Canada Potash Co. Limited	Viscount	1969	1,500,000	900,000	437,566	48.7
Hudson Bay Mining and Smelting Co., Limited	Rocanville	1970	1,200,000	732,000	297,541	40.6
Total or average			13,680,000	8,324,200	3,626,000[4]	43.2[4]

[1]All in Saskatchewan. [2]Shut down most of the year for shaft maintenance. [3]Shut down for mine rehabilitation following flooding in 1970; Cominco's production allowable was largely transferred to Duval Corp. [4]These production allowables include only the basic quota and sales allowable; supplemental allowables are excluded and for this reason the grand total will differ from actual output.

Table 5. Canada, consumption of potash fertilizers, years ended June 30, 1962-1971.

	In Materials	In Mixtures	Total
	(short tons of K_2O equivalent)		
1962	6,558	99,934	106,492
1963	9,704	102,285	111,989
1964	14,087	106,609	120,696
1965	18,264	117,142	135,405
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	40,306	153,843	194,149
1971	46,831	156,362	203,193

Source: Statistics Canada.

from domestic sources, but rising railway transportation rates in Canada have made east coast markets less accessible for Saskatchewan producers. Potassium sulphate imports decreased significantly in 1971 and are expected to decrease further as output from a newly built Ontario plant becomes fully operational.

The United States is Canada's leading export market for potash, followed by Japan. In 1971, 2.75 million tons K_2O equivalent, representing about 69 per cent of Canada's potash sales went to the United States and 368,000 tons representing 9.3 per cent of sales went to Japan. Except for some high-grade industrial potash, shipments to western Europe all but ceased in 1970 following the imposition of production controls and a floor price on Saskatchewan potash. Sales to western Europe resumed on a significant scale in July 1971, following conclusion of an agreement with the French potash sales organization. The agreement reportedly provides for the purchase of 300,000 tons of potassium chloride annually for a 3-year period. Most Canadian deliveries to western Europe are shipped to bulk terminal facilities in Rotterdam, Netherlands, thence to their final destination.

World review

Preliminary figures reveal that 19.1 million metric tons K_2O equivalent were produced in 1971, up 8.4 per cent from the previous year's output of 17.6 million metric tons. In absolute terms, it is the second largest increase on record, the largest increase being for the year 1965.

By far the largest increase was in the U.S.S.R., where output has expanded sharply during the past three years, rising from 3.2 million metric tons K_2O equivalent in 1969 to 4.1 million metric tons in 1970 and 4.8 million metric tons in 1971. Similar increases are expected for the years ahead as new mines are brought on stream and others are expanded.

In East Germany, output expanded moderately in 1971; a significant increase is expected for 1972 when production starts from a new deposit near Magdeburg, some 85 miles north of Erfurt, the hub of the East German potash industry.

Table 6. Canada, potash deliveries by product and area, 1970-71

(short tons of K_2O equivalent)

		Agriculture						
		Potassium Chloride						
		Standard	Coarse	Granular	Soluble	Potassium Sulphates	Total Agricultural	Industrial
Atlantic provinces	1970	2,689	20,784	–	–	2,291	25,764	–
	1971	2,405	32,712	–	–	639	35,756	–
Quebec	1970	12,140	30,699	426	77	2,670	46,012	177
	1971	8,604	31,116	813	–	2,421	42,954	291
Ontario	1970	18,602	86,455	2,515	556	7,195	115,323	2,174
	1971	15,794	97,812	484	41	7,659	121,790	5,438
Prairie Provinces	1970	2,818	4,345	2,801	364	156	10,484	20
	1971	7,225	2,173	3,294	6,979	126	19,797	1,764
British Columbia	1970	1,625	2,625	596	126	269	5,241	–
	1971	777	4,159	512	188	413	6,049	52
Totals	1970	37,874	144,908	6,338	1,123	12,581	202,824	2,371
	1971	34,805	167,972	5,103	7,208	11,258	226,346	7,545

Source: Potash Institute of North America.
– Nil.

Table 7. World potash production, 1967-71

	1969	1970	1971^p
	('000 metric tons K_2O equiv.)		
U.S.S.R.	3,244^r	4,087	4,800
Canada	3,400^e	3,173	3,573
United States	2,544	2,476	2,450
East Germany	2,346	2,419	2,450
West Germany	2,283	2,306	2,443
France	1,794	1,765	1,850
Israel	363	546	565
Spain	551	521	505
Congo	40^r	123	258
Italy	175	139	150
Others^e	100	100	100
	16,840^r	17,655	19,144

Source: Saskatchewan Department of Mineral Resources, U.S. Bureau of Mines and the Journal of World Phosphorus and Potassium.
^{p}Preliminary; ^{e}Estimated; ^{r}Revised figures.

In western Europe, output reached an alltime high in 1971 with most of the expansion taking place in West Germany, where a record 2.4 million metric tons K_2O equivalent were produced, up 6 per cent from 1970. Output from France was up almost 5 per cent from 1970 while Spanish production declined slightly. The Spanish industry has undergone some reorganization and expansion during the past few years, and although output has repeatedly fallen short of projected targets, significant increases can be expected when marketing conditions improve.

In the Republic of Congo production continued to expand following the 1969 startup of a new potash mine. The operators of the mine have apparently encountered severe mining difficulties and there is some doubt whether output will ever reach designed capacity of 500,000 metric tons K_2O equivalent annually. Israeli potash production, after rising sharply from 1969 to 1970, increased moderately in 1971 to a record 565,000 metric tons K_2O equivalent; only moderate increases are expected in the next few years.

United States potash output had peaked at 3.0 million metric tons K_2O equivalent in 1966 and 1967 and then dropped considerably in 1968 as a result of cutbacks at some Carlsbad, New Mexico mines, the hub of the United States industry. In the period 1969-71, output from New Mexico expanded again but those increases were offset by the mid-1970 closure of Texas Gulf Sulphur Company's Moab, Utah mine, which was being converted from conventional mining methods to a solution-mine; it was expected to be reopened early in 1972. Great Salt Lake Minerals & Chemical Corporation completed construction in 1971 of a $35-million brine recovery complex at Little Mountain, Utah, on Great Salt Lake; the complex includes a 220,000-ton-a-year potassium sulphate plant. With the reopening of the Texas Gulf mine and full operation of the Great Salt Lake venture, potash output in the United States is expected to increase in 1972 and to remain temporarily at a higher level than in the 1968-71 period, which averaged 2.5 million metric tons K_2O annually.

Construction of Britain's first potash mine near Staithes, Yorkshire, was reported to be on schedule in preparation for startup in 1973; it will be operated by Cleveland Potash Ltd., a joint venture financed by Charter Consolidated Ltd. and Imperial Chemical Industries Ltd. The twin-shaft, $60 million mine has been designed to produce 1.0 million tons of potassium chloride annually, a quantity sufficient to supply the entire British market. Two other companies, Yorkshire Potash Limited and Whitby Potash Ltd., had undertaken to develop a second and third mine in the same area but towards the beginning of 1971 postponed their plans.

Outlook

The outlook for Canadian potash producers is mixed. A tight supply situation in western Europe that arose following the failure of some producers to meet output targets reopened the door temporarily for some Canadian potash but these sales should be viewed as short-term gains only. Increased output from the U.S.S.R. and East Germany is displacing some west European sales in eastern Europe and the Israeli and Congolese industries are continuing to make significant gains in some Asian, African and European markets. To a large extent, the fortunes of Canadian potash in western Europe depend upon the ability of Congolese and Spanish producers to achieve output goals and the success of the mine under construction in England.

The logical outlets and largest markets for Saskatchewan potash lie in the midwestern and eastern seaboard states of the United States and in the Pacific rim countries. With respect to the United States, the Canadian industry can look forward to capturing virtually all of that country's total increase in consumption, which is expected to rise at an average of about 4 per cent annually during the remainder of the 1970's. Although an expected increase in output in the United States in 1972 will be earmarked for domestic sales, production from the New Mexico mines is likely to decline after the mid-1970's provided that Canadian potash prices are not further boosted or maintained at levels that keep the less efficient mines operating. Perhaps the most significant potential gains for Saskatchewan potash in the medium and long term rests in established Pacific rim market areas and hopefully in the People's Republic of China. To date considerable quantities of west European potash have continued to flow into Pacific markets that might better be served from Canada.

Rationalization of Canadian offshore marketing efforts to the extent that total distribution costs are reduced or at least maintained at current levels and deliveries ensured, should lead to an expansion of Saskatchewan potash sales in the Pacific area. The Saskatchewan-based producers have thus far favoured individual sales initiative, when on many occasions they face large monopolistic buyers and must compete with large-selling organizations representing foreign potash industries. An attempt to rationalize some offshore sales was made in 1970 with the creation of Canpotex Limited as a marketing and distributing arm of most Saskatchewan-based producers; Canpotex represents its membership in bidding for Canadian foreign aid contracts and other foreign government tenders. Further rationalization and co-ordination of offshore shipments through Vancouver are likely to curb rising transportation and distribution costs, thereby enhancing Saskatchewan's competitive position particularly in the Pacific area.

Prices

A ministerial notice posted by the Minister of Mineral Resources, Province of Saskatchewan, on November 25, 1969, stipulated that a fair and reasonable price to the producer of potash, fob mine should be not less than 33.75¢ Can. per unit K_2O equivalent.

This floor price was applied to standard and special standard grades during the off-season summer months, with the most desirable grades commanding higher prices. Although each producer posted as many as three price schedules during the year and the occasional schedule differed from one producer to another, the following is indicative of posted prices for 1971 and the first half of 1972. Muriate of potash, bulk, carload lots, fob mine, Saskatchewan, per unit (20 lbs) K_2O

(% K_2O min.)	Jan.	Feb.-June	July-Aug.	Sept.-Jan/72	Feb.-June
	(¢)	(¢)	(¢)	(¢)	(¢)
Standard 60-62	33.75	36	33.75	35	37
Coarse 60-62	40	43	37	39	42
Granular 60-62	42	45	38	40	43
Soluble 62	38	41	35	36	38

Actual prices were, however, somewhat lower than posted prices; especially in the February-June period; for example, April 1971 sales of coarse muriate averaged 42.2¢ a unit while granular muriate averaged 43.3¢ a unit. Prices also fell below posted schedules in the September-December period. The above-indicated increase from August to September failed to materialize following a 90-day price freeze announced by President Nixon in mid-August. Since the bulk of Saskatchewan potash is sold in the United States and Canadian producers must compete for markets in that country with New Mexico producers, the price freeze automatically affected the Canadian industry as well. December 1971 sales of coarse muriate averaged 34.5¢ a unit.

Rare Earths

ROBERT J. SHANK

The rare earth elements, sometimes called the lanthanides, are a group of 15 chemically similar metals having atomic numbers 57 to 71 in Group III B 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.

By comparison, cerium is more abundant than tin or cobalt and almost three times as abundant as lead. Thulium, the least common of the rare earths, is more abundant than silver. Thus, the rare earths are not 'rare', and they are not 'earths' but metals. 'Earth' is the old chemical term for 'oxide' and the rare earth elements were discovered as oxides.

All the rare earths will be present in a particular mineral, but either the light (cerium) group or the heavy (yttrium) group will predominate. In general, granitic rocks are the most favourable for the concentration of the heavy rare earths; alkalic rocks and carbonatites tend to concentrate the cerium group. The relative abundance of the various rare earths in the ores presently being mined has no relationship to the market demand for the individual products. As a result, some rare earth products are readily available at low cost, while others, particularly high-purity separated compounds, are available at higher cost. For some compounds, no significant market has yet been found. The problem has been, first, to develop

Rare earth elements

Atomic No.	Name	Abbreviation	Abundance in Igneous Rocks
	Light rare earths		(ppm)
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

markets for those compounds that are available and second, to find and develop sources of supply to meet changing industrial requirements.

A substantial increase in demand for products of the rare earth industry has occurred since 1963. Mine production and potential sources of production multiplied along with processing capacity. The main growth in dollar value was in high-priced, high-purity oxides of yttrium and europium for television phosphors. Oversupply began to affect producers in 1967 when the electronics industry realized that stocks of phosphors were excessive in relation to short-term market projections. Also, technological improvements in phosphor compositions resulted in a lowering of requirements. There was a pyramiding effect back through the supply pipeline so that ore supplies dependent upon the market for phosphors, particularly those containing yttrium, were faced with diminishing markets.

In the same period, lower-priced rare earth products showed a marked increase in demand, such as for applications in the glass industry and in catalysts for the petroleum refining industry. The availability of high-purity compounds of all the rare earths resulted in increased basic research that will lead to future markets.

Canadian industry

From 1966 to 1970, the world's major source of yttrium-bearing concentrate was the uranium mines in the Elliot Lake district of Ontario. All rare earths, except promethium, have been detected in these ores which contain the minerals uraninite, uranorthite, brannerite and monazite. The rare earths and thorium can be recovered from effluent solutions following uranium extraction. Variable recoveries are possible depending upon the method used, but yttrium oxide was the only rare earth of commercial value that was recovered. The Elliot Lake ores contain about 0.11 per cent uranium oxide (U_3O_8), 0.28 per cent thorium oxide (ThO_2) and 0.057 per cent rare earth oxides (REO). The distribution of the individual rare earths in the REO varies, but approximates 20 to 40 per cent yttrium oxide, 20 per cent cerium oxide, 10 to 20 per cent neodymium oxide, with the others seldom exceeding 5 per cent.

There are no facilities in Canada for the separation of the individual rare earths from each other, and thus all output is exported. Denison Mines Limited, the only Canadian producer of rare earth concentrates in recent years, ceased production of these byproducts in mid-1970, when it experienced difficulty in marketing the product. Denison shipped some concentrate in 1971 but the quantity and value has not been reported. During 1966 and 1967, Rio Algom Mines Limited recovered thorium and REO at its Nordic mill, but did not resume production when the milling of uranium ores was transferred to the Quirke mill.

Shipments of rare earth concentrate since 1965 are summarized in the following table:

	Y_2O_3 in Concentrate	Value
	(pounds)	($)
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
1965	–	–

... Not reported; .. Nil.

This reduction in shipments reflects the oversupply existing in world markets for yttrium and the heavy rare earths in a bulk concentrate. It is possible that better marketing conditions might exist if the various REO's were separated and offered individually.

Besides the large potential of the Elliot Lake uranium ores, rare earths are also associated with uranium deposits at Agnew Lake, 40 miles east of Elliot Lake, where the REO content is about twice that of Elliot Lake ores, in the Bancroft area of Ontario, and at one deposit in British Columbia. At Nemegos, Ontario, the apatite in a magnetite-apatite zone contains 4.1 per cent REO. 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 the rare earth content of apatite or pyrochlore associated with carbonatite rocks.

Few laboratories are equipped to analyze samples containing rare earth elements. Assay results can be misleading unless the laboratory is provided with information on the mineralogy or chemistry of the test material.

World industry

The minerals monazite and bastnaesite are the main sources of the cerium group of rare earths. These may be processed to recover mixed rare earths for low-value products such as mischmetal or may be further processed at much higher cost to separate individual rare earths. The two methods of recovery, for higher-purity compounds, are solvent extraction and ion exchange, or combinations of these.

Australia is the main source of monazite. Recovery is a byproduct of mining beach sands for rutile and zircon. In the United States, there is some recovery from beach sands in Georgia and from molybdenum mining in Colorado. Some Indian beach sands are mined; the concentrates are treated either domestically or in Japan. Brazilian production is processed domestically. Small parcels from other countries do not add materially to supply. As monazite of placer origin is relatively low-cost, lode deposits are currently uneconomic.

The mine of Molybdenum Corporation of America (Molycorp), at Mountain Pass, California is the main source of concentrates for cerium group rare earths and, unlike monazite, 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 is cerium 48, lanthanum 32, neodymium 13.1, praseodymium 4.5, samarium 0.5, gadolinium 0.2, europium 0.1, other-yttrium group 0.3.

The adjacent mill produces a flotation concentrate grading 60 per cent rare earth oxide, a leached concentrate grading 70 per cent and a calcine grading 90 per cent. 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 and York, Pennsylvania.

During 1969 Molycorp made arrangements with Republic Steel Corporation to treat tailings dumps at Republic's iron mining operation at Port Henry, New York, for their heavy rare earth content. Molycorp has until June 30, 1972 to make its final decision whether or not to proceed on the project. That decision will hinge largely on further market development for the heavy rare earths.

The Finnish producer Typpi Oy, is the only company that recovers rare earths by solvent extraction as a product of producing phosphate fertilizer from apatite. The source of the apatite is the apatite-nepheline mines in the Kola Peninsula of the U.S.S.R. Many companies produce fertilizer from this source but do not recover the rare earth content. Other sources of phosphate rock, such as those from Florida, contain lesser amounts with a different rare earth distribution.

Xenotime, valuable for its yttrium content, is recovered from heavy mineral rejects in concentrating placer tin in Malaysia and from retreatment of monazite concentrate, itself a byproduct, from Western Australia. Such concentrates are usually treated in Europe or Japan.

A few uranium mines have rare earths as a potential byproduct, not in the form of a mineral concentrate, but as a chemical precipitate from treating barren liquors following uranium extraction. While such precipitates are free of thorium, the thorium content of the ore must be removed prior to rare earth recovery. Canadian production is of this type. Potential sources in Australia are Mary Kathleen Uranium Limited and Field Metals and Chemicals Pty. Limited. Should markets for scandium develop, thorveitite, a mineral found in Norway, is a possible source. This element is mainly used in basic research. Commercial applications have been negligible but a market may develop from an improved mercury arc light now being tested which contains scandium as well as mercury, thorium and sodium.

Other rare earth minerals such as euxenite, samarskite, and fergusonite are occasionally available but they are difficult to treat and markets for these yttrium group rare earths are limited.

It is worth noting that promethium isotopes have half-lives ranging from seconds to 18 years. Accordingly, its natural occurrence is extremely minute. 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.

The main world processors of rare earth ores and concentrates include: in the United States, American Metallurgical Products Co., Inc., American Potash and Chemical Corporation (Rare Earth Division), W. R. Grace and Company (Davison Chemical Division), Michigan Chemical Corporation, Molybdenum Corporation of America, Ronson Metals Corporation (Cerium Metals and Alloys Division), Nuclear Corporation of America (Research Chemicals Division; in Austria, Treibacher Chemische Werke Aktiengesellschaft; in France, Produits Chimiques Pechiney St. Gobain, Etablissements Tricot; in West Germany, Th. Goldschmidt A.G., Otavi Minen and Eisbahn Ges.; in Finland, Typpi Oy; in Britain, British Rare Earths Limited, London and Scandinavian Metallurgical Company, British Flint and Cerium Manufacturers Limited, Rare Earth Products Limited (a joint venture of Thorium Ltd. and Johnson Matthey Chemicals Limited); in Japan, Shin-Etsu Chemical Industry Company, Nippon Yttrium Company, Ogino Chemical Company, Santoku Metal Industry Company; in India, Indian Rare Earths Limited; in Brazil, Commissao National de Energia Nuclear (Industrias Quimicas Reunidas). Production in the U.S.S.R. is state-controlled and output is sold through Techsnabexport.

Uses

Rare earths are consumed mainly as oxides, the form in which they are produced by chemical extraction from the mineral concentrates. The purity of the various REO mixtures is usually expressed in terms of total REO content; the individual rare earths are present in about the same proportions as they occur in the originating concentrates. Mixtures are used in glass-polishing compounds, for the production of mischmetal, and as alloying agents in nodular iron, steel and magnesium. Mischmetal, which is mostly cerium, lanthanum and neodymium, has a stable use in lighter flints. Refined rare earth chlorides of lanthanum, neodymium and praseodymium are used in petroleum refineries to increase the yield of gasoline during the distillation process.

The main metallurgical uses are those involving cerium in the preparation of nodular iron, and yttrium and neodymium as hardeners in magnesium alloys. Mischmetal is added to high-strength low-alloy steels used for oil and gas pipelines in arctic or cold regions and under water. The addition of lanthanum to a new atomized spherical copper-base brazing provides a cleaning action and promotes grain refinement to the brazed alloy. In marine turbine applications, corrosion rate may be reduced by a factor of ten by the addition of 0.1 to 0.2 per cent yttrium to cobalt-base alloys, and of lanthanum or cerium to nickel-base alloys. Samarium-cobalt permanent magnets are now in use that have twice the strength of any conventional permanent magnets. These magnets can be formed by melting the constituents as metals and casting, or by pressing the constituents as metal powders to shape. Gadolinium and europium are used in control rods in nuclear reactors.

Research in the United States has indicated that certain combinations of rare earth elements with cobalt or manganese show promise as catalysts for removing carbon monoxide from automobile exhausts. Much testing of these catalysts remains to be done.

Artificial garnets containing yttrium and gadolinium are used in microwave devices. One application of yttrium-aluminum-garnets (YAG's) is in the jewelry trade replacing spinel crystals. YAG's have slightly less lustre than spinel but are harder, being about 8.9 on Mohs scale.

Varied and growing applications are evident in the glass industry, ranging from the use of cerium to neutralize the effects of iron impurities to the absorption of ultraviolet rays in bottles by additions of cerium and praseodymium to coloured glass. Praseodymium imparts a yellow-green colour, neodymium a lilac-purple, europium an orange-red, and erbium a pink. Lanthanum is a major component of optical glass and cerium glass has application as windows in atomic reactors.

A low-volume application is in the electronic field, where rare earth oxides are used as phosphors in colour television tubes, temperature compensating capacitors and associated circuit components. Yttrium aluminate crystals doped with neodymium are a laser-grade material which is said to have exceptional qualities for this application. Cerium oxide is a hydrocarbon catalyst used in modern self-cleaning ovens. Europium-doped phosphors are being used to obtain an improved X-ray image with a lower X-ray dosage. Promethium combined with silicon in layers shows promise in a cardiac pacemaker. It is anticipated that this cell will operate continuously for up to 10 years, compared with 18 to 30 months by the standard mercury battery for this device. It was reported that an efficient process for phosphate removal from sewage and waste water is possible using a lanthanum chemical.

Rare earth elements and their compounds have many unusual magnetic, optical and nuclear properties. Research to date has only examined a little of the potential for new uses of these materials.

Prices

Prices for rare earth concentrates, as quoted in *Metals Week* of December 20, 1971, were unchanged from those quoted late in 1970. Monazite sand cif United States ports remained at $180 to $200 a long ton. Bastnaesite concentrates, fob Nipton, California were quoted at 30 cents a pound for 55 to 60 per cent grade and 35 cents a pound for 68 to 72 per cent grade. Rare earth oxide fob Nipton, California assaying 88 to 92 per cent REO was quoted at 45 cents a pound.

Prices of the refined products vary considerably, depending upon purity, demand, and whether in the oxide or metal state. Some typical prices as given in the *American Metal Market* for January 3, 1972 are as follows, per pound: mischmetal $3.10; 99.9 per cent cerium oxide $6; cerium metal $21; 99.9 per cent yttrium oxide $32; yttrium metal $150; 99.9 per cent lanthanum oxide $4.15; lanthanum metal $35; 99.9 per cent samarium oxide $38; samarium metal $125; 99.9 per cent thulium oxide $1,350; thulium metal $2,750.

Salt

W.E. KOEPKE

Demand for salt to control snow and ice on highways and city streets was especially strong in Canada and the northern United States in the winter months of 1971 and output increased accordingly. Imports showed a marked increase, particularly from United States producers who border the lower Great Lakes and are able to take advantage of low shipping costs to gain spot sales in southern Ontario and Quebec markets. An unusual shipment of 56,000 tons of salt was imported from Romania; it was unusual in the sense that the low unit value of salt and its availability in North America seldom permits imports of this commodity from distant countries. Canada's salt exports, although down in 1971 from the previous year, were substantially higher in 1970 and 1971 than throughout the 1960's. The bulk of Canada's exports go to the United States; prior to 1969, a large part of these exports was in the form of brine, whereas in subsequent years they have consisted mainly of mined rock salt.

Canada's salt industry in 1971 can be summarized as follows: three rock salt mines and seven evaporator plants were operated at or near capacity; one rock salt mine was being expanded; the management of one brining operation for caustic soda - chlorine was contracted out to another firm; and significant quantities of byproduct salt from a potash mine were marketed.

Production and developments in Canada

Canadian salt production falls into three statistical classes: mined rock salt, fine vacuum salt and salt content of brines used or shipped plus salt recovered in chemical operations. In Table 3 plants described as brining for vacuum pan evaporation are classified as producers of fine vacuum salt, the other two classes being self-explanatory. Total salt production (shipments) in Canada in 1971 was 5,578,000 tons valued at $38.6 million, both the tonnage and value being considerably higher than in 1970. Production of mined rock salt accounted for almost three quarters of Canada's total salt output and amounted to 4,066,000 tons in 1971 compared with 3,607,336 tons in 1970. Output of fine vacuum salt increased only marginally while salt in brines decreased markedly, largely because of a cutback in the production of caustic soda and chlorine at the Dow Chemical of Canada, Limited plant at Sarnia, Ontario.

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 salt output, underground

Table 1. Canada, salt production and trade, 1970-71

	1970		1971ᵖ	
	(short tons)	($)	(short tons)	($)
Production (shipments)				
By type				
Mined rock salt	3,607,336	19,098,483	4,066,000	..
Fine vacuum salt	609,252	13,257,986	625,000	..
Salt content of brines used or shipped and salt recovered in chemical operations	1,142,308	3,741,348	887,000	..
Total	5,358,896	36,097,817	5,578,000	38,605,000
By province				
Ontario	4,158,157	22,700,000	4,172,000	23,029,000
Nova Scotia	684,495	7,671,636	889,000	9,201,000
Saskatchewan	203,195	3,224,307	228,000	3,990,000
Alberta	283,738	2,281,138	262,000	2,219,000
Manitoba	29,311	220,736	27,000	166,000
Total	5,358,896	36,097,817	5,578,000	38,605,000
Imports				
Total salt and brine				
United States	291,878	2,154,000	496,182	3,063,000
Mexico	299,497	550,000	341,347	504,000
Romania	–	–	55,995	175,000
Spain	25,121	101,000	15,135	74,000
Italy	–	–	9,512	72,000
West Germany	1,043	17,000	294	15,000
Bahamas	–	–	2,128	14,000
Norway	400	12,000	349	7,000
Other countries	82	6,000	1,071	7,000
Total	618,021	2,840,000	922,013	3,931,000
Exports				
United States	..	7,131,000	..	6,940,000
Cuba	..	231,000	..	2,000
New Zealand	..	22,000	..	4,000
Leeward and Windward Islands	..	10,000	..	5,000
Nigeria	..	9,000	..	38,000
Other countries	..	27,000	..	40,000
Total	..	7,430,000	..	7,029,000

Source: Statistics Canada.
ᵖPreliminary; .. Not available; – Nil.

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 Quebec and British Columbia. They have also been found in the District of Mackenzie, Northwest Territories, and there is geological evidence that suggests the presence of 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. Small quantities are produced from natural subsurface brines in Manitoba. In past years, salt has been recovered from brine springs in Nova Scotia, New Brunswick, Ontario, Manitoba, Saskatchewan and Alberta. Salt springs are also common to southwestern Newfoundland and in certain parts of British Columbia.

Ontario. Thick salt beds underlie much of southwestern Ontario extending from Amherstburg northeastward to London and Kincardine, bordering on

Table 2. Canada, salt production and trade, 1962-71

	Production[1]				Imports	Exports
	Mined Rock	Fine Vacuum	In Brine & Recovered in Chemical Operations	Total		
	(st)	(st)	(st)	(st)	(st)	($)
1962	1,845,393	463,093	1,013,896	3,322,382	245,836	3,987,668
1963	1,771,242	486,940	1,132,537	3,390,719	332,581	3,701,356
1964	1,874,225	537,553	1,225,365	3,637,143	405,574	3,618,569
1965	2,399,919	558,346	1,289,796	4,248,061	441,601	4,996,509
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
1971p	4,066,000	625,000	887,000	5,578,000	922,013	7,029,000

Source: Statistics Canada.
[1]Producers' shipments.
pPreliminary.

what is known geologically as the Michigan Basin. As many as six salt beds, occurring in the Salina Formation of Upper Silurian age and at depths ranging 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 thereby permitting easy exploitation.

In 1971, these beds were being exploited through two rock salt mines, one at Goderich and one at Ojibway, and through brining operations at Goderich, Sarnia and Windsor. Domtar Chemicals Limited was in the midst of a $5.8 million expansion program which will boost the productive capacity of its Goderich salt mine to 2.25 million tons of salt annually by 1972.

Atlantic provinces. Salt deposits occur in isolated sub-basins of a large sedimentary basin that underlies the northern mainland of Nova Scotia, and extends westward under the bordering areas of New Brunswick and northeastward under Cape Breton Island. The sub-basins are Weldon-Gautreau and Westmorland in New Brunswick; and Cumberland, Minas, Antigonish-Mabou and Sydney in Nova Scotia. The Nova Scotia deposits occur within the Windsor Group of Mississippian age and are generally folded and faulted. The deposits appear to be steeply dipping tabular bodies or domes and brecciated structures of rock salt; depths range from 85 feet to several thousand feet with thicknesses up to 1,500 feet.

The rock salt deposits in Prince Edward Island occur at a depth of over 14,000 feet, and in southeastern Newfoundland, salt has been found in the St. Fintan's area at a depth of about 1,000 feet. The latter deposit occurs within the same rock sequence as those in Nova Scotia and is believed to be of the tabular-dome type.

Exploitation of salt deposits in the Atlantic provinces in 1971 was confined to one rock salt mine and an associated evaporator plant at Pugwash, Nova Scotia, and a brining operation at Amherst, Nova Scotia. During the last few years, Domtar Chemicals Limited has been actively exploring salt deposits in Cape Breton Island and the company has apparently acquired a concession in anticipation of developing a commercial operation. In New Brunswick, the Department of Natural Resources headed a joint federal-provincial exploration program, in which two test holes drilled in Kings County early in 1971, encountered thick sections of salt. The beds also contain significant thicknesses of potash; further exploration of these beds is expected.

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 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

Table 3. Canada, summary of salt producing and brining operations, 1971

Company	Location	Initial Production	Remarks
Nova Scotia			
The Canadian Rock 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.	Amherstburg	1919	Brining to produce soda ash
The Canadian Rock 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
Dome Petroleum Limited	Sarnia	1969	Brining to develop storage cavity
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			
Dryden Chemicals Limited	Brandon, Man.	1968	Pumping natural brines to produce caustic soda and chlorine
Northern Industrial Chemicals Ltd.	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.	1948	Brining, vacuum pan evaporation and fusion
Dow Chemical of Canada, Limited	Ft. 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

6,000 feet around Edmonton, Alberta, and across to 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.

These rock salt deposits were being exploited at four locations in the Prairie Provinces in 1971 – Saskatoon and Unity, Saskatchewan, and Lindbergh and Ft. Saskatchewan, Alberta. In addition, naturally occurring subsurface salt brines in Manitoba were being used to produce brine 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. Elsewhere in Saskatchewan, waste salt from potash mining has occasionally been used; in 1971, significant quantities were sold by International Minerals & Chemical Corporation (Canada) Limited, at Esterhazy, presumably for snow and ice control on roads. Management of the Saskatoon caustic soda and chlorine plant owned by Northern Industrial Chemicals Ltd., for-

Table 4. World salt production, 1969-71

	1969	1970^p	1971^e
	(thousands of short tons)		
United States	44,276	45,836	44,064
People's Republic of China	16,500	17,600	. .
U.S.S.R.	13,228	14,300^e	. .
Britain	8,834	9,301	9,700
West Germany	9,214	10,948	11,500
India	7,033	6,160	6,400
France	5,382	5,602	5,800
Canada	4,657	5,359	5,334
Italy	4,350	4,815	5,000
Other countries	35,315	36,751	71,200
Total	148,789	156,672	158,998

Source: U.S. Bureau of Mines *Minerals Yearbook* Preprint 1970, and U.S. Bureau of Mines Commodity Data Summaries, January 1972.
^{p}Preliminary; ^{e}Estimated.
. . Not available.

merly operated by Interprovincial Co-Operatives Limited, was contracted out to Canadian Industries Limited, in 1971.

Recovery method

Canadian producers employ three different methods for the recovery of salt from depth for the production of dry salt and for direct use in the chlor-alkali industry. The method employed depends upon the deposit and the type of salt required by the consumer. Conventional mining methods are used to mine rock salt deposits that are relatively shallow and are located in areas convenient to large markets that do not require a high-purity product.

Brining methods are used to recover salt from subsurface deposits as well, usually from greater depths. The brine can be evaporated to produce high-purity fine vacuum salt or can be used directly in the manufacture of chemicals. Salt is similarly recovered from natural subsurface brines.

A third method of recovering salt is as a coproduct of potash mining, a practice quite common in Europe. In Canada, this technique is being used on a commercial scale at only one potash mine, of the solution type, which lends itself to 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 is by solar evaporation of sea or salty lake waters, a process commonly used in warm, arid climates.

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 room-and-pillar dimensions being dependent upon 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 rates range 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 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 by crushing and screening; removal of the remainder from small amounts of the coarser salt fractions is achieved with electronic sorters.

Most of the mined rock salt in Canada is shipped in bulk by water, rail and truck, much of it being used for snow and ice control.

Brining and vacuum pan evaporation. Brining is essentially a system of injecting water into a salt deposit to dissolve the salt and then pumping a saturated salt solution to the surface. Water injection and brine recovery can be accomplished in a single borehole with casing and tubing or in 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 feet to 6,500 feet. Saturated salt brine contains 26 per cent NaCl, which amounts to about 3 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 purified to remove gypsum and other impurities and then fed into a series of three of four large cylindrical steel vessels under vacuum for a triple or quadruple effect evaporation. The salt crystallizes and is removed as a slurry; it is then 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 producing 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

Table 5. Canada, available data on salt consumption, 1968-71

	1968	1969	1970e	1971e
	(st)	(st)	(st)	(st)
Industrial chemicals	1,737,685	1,735,117	1,760,000	1,800,000
Snow and ice control[e]	1,600,000	1,800,000	1,950,000	2,200,000
Slaughtering and meat packing	51,735	46,609	50,000	50,000
Food processing				
Fish products	17,337	20,559	20,000	25,000
Bakeries	14,656	14,928	15,000	15,000
Miscellaneous food preparations	15,994	17,541	18,000	19,000
Fruits and vegetable preparations	19,742	20,554	21,000	22,000
Other food processing	3,279	3,224	3,300	3,500
Breweries	643	649	700	700
Dairy factories and process cheese	9,015	11,912	12,000	12,000
Leather tanneries	9,437	7,957	9,000	9,000
Soaps and cleaning preparations	2,780	2,812	3,000	3,000
Dyeing and finishing textiles	1,499	1,502	1,500	1,500
Artificial ice	700	728	700	700
Pulp and paper mills	54,542	58,725	60,000	65,000
Feed and farm stock	48,504	48,301	50,000	55,000
Flour mills	1,662	1,597	1,600	1,600
Fishing industry[e]	75,000	80,000	80,000	90,000

Source: Statistics Canada.
[e]Estimated.

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 2.2 million tons in 1971.

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 or 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.

In the five years prior to 1968, Canada exported about 1.4 million tons of salt annually to the United States; about one half was in the form of salt brine to feed a soda ash plant in Detroit, the balance consisting largely of mined rock salt. Brine sales ceased in 1968 and exports to the United States declined significantly in 1969, but regained sharply in 1970. Nearly all of Canada's exports to the United States in 1970-71 were mined rock salt. Salt exports to other countries normally involve small quantities of fine salt.

Salt imports into Canada climbed steadily from 192,000 tons in 1960 to 696,000 tons in 1969, fell to 618,000 tons in 1970 and then rose sharply to 922,000 tons in 1971. From 1963 to 1969, our imports consisted mainly of: fishery salt for the Atlantic provinces from Spain (about 40,000 tons yearly); solar salt for use in fisheries and west coast industrial chemical plants from Caribbean countries and Mexico (rising from 118,000 to 356,000 tons); and rock salt from the United States (rising from 166,000 to 291,000 tons). Imports from Spain declined markedly in 1970 and 1971, while those from the United States increased sharply from 292,000 tons in 1970 to 496,000 tons in 1971; United States producers bordering on the lower Great Lakes are able to take advantage of low shipping rates to capture spot sales in southern Ontario and Quebec, particularly for snow and ice control salt in large metropolitan areas. Imports from Mexico also increased in 1971 at the expense of Caribbean countries, and 56,000 tons were acquired from Romania.

Outlook

The outlook for Canada's salt industry is generally favourable, but recent actions of some United States producers in the lower Great Lakes region have added a dimension of uncertainty. Sporadic shipments have been made into Ontario and Quebec markets during recent years and are likely to increase following the start-up in 1971 of a 2.5 million-ton-a-year salt mine in the Seneca Lake region of New York State. Strong demand for snow and ice control salt is, however, expected to result in higher Canadian output for the years ahead, not only to supply domestic markets but also those in certain parts of northern United States. It would seem logical that rock salt trade between Canada and United States could increase to the advantage of both producers and consumers where mines are strategically located to serve regional markets. Unfortunately, the full advantages of free trade cannot be realized because Canadian producers face a tariff when exporting to the United States.

Tariffs

The Kennedy Round of the General Agreement on Tariffs and Trade (GATT), that was convened in 1964 to consider reductions in tariffs, submitted its report in 1967. Agreement was reached on a series of tariff reductions on salt with reductions beginning on January 1, 1968. In the 5-year period ended December 31, 1971, Canada eliminated tariffs for MFN countries on all types of salt, with the exception of specialty mixtures for which the duty was lowered from 10 per cent to 5 per cent ad valorem. During the same 5-year period, tariffs on salt imports into the United States were lowered, but some protection for domestic producers still exists.

Canada

Item No.		British Preferential	Most Favoured Nation	General
			(¢ per 100 lb)	
92501-1	Common salt (including rock salt)			
	On and after Jan. 1, 1971	free	½	5
	On and after Jan. 1, 1972	free	free	5
92501-2	Salt for use of the sea or gulf fisheries	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
	On and after Jan. 1, 1972	5	5	15
92501-4	Salt liquors and sea water	free	free	free

United States

Item No.		On and After Jan. 1, 1971	On and After Jan. 1, 1972
420.92	Salt in brine	6%	5%
		(¢ per 100 lb)	
420.94	Salt in bulk	1	0.8
420.98	Salt, other	0.5	free

Sources: The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa, Canada. Tariff Schedules of the United States annotated (1972) TC Publication 452.

Sand and Gravel

D. H. STONEHOUSE

Sand is defined as granular mineral material resulting from the natural disintegration and abrasion of rock or the processing of completely friable sandstone, 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 defined as granular material resulting from similar processes and predominantly retained on a No. 4 sieve, the cutoff between commercial sand and gravel. Material finer than 200-mesh is called 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. Those that are composed of sand and gravel that has been carried by rivers and stream 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 boulders, pebbles, sand and clay, 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 mass.

Construction activity in Canada, particularly in the heavy, or engineering, construction category, regulates the production of sand and gravel. An upward trend in output experienced during the 1960's peaked in 1966 and 1967 in support of major requirements for the Expo '67 construction surge. Demand decreased during post-Expo years and will tend to stabilize to a more normal annual increment, closely related to the volume of construction performed. Work stoppages and labour unrest in the construction industry, combined with the high costs of construction, have had a dampening effect on the industry with a resultant decrease or levelling in demand for all mineral aggregates.

Total sand and gravel production for 1971 is estimated at 201,450,000 tons valued at $134,250,000.

Construction Spending by Province:

	1970	1971ᵖ	1972ᵉ
	(millions of dollars)		
Newfoundland	416	540	594
Prince Edward Island	45	57	67
Nova Scotia	485	466	526
New Brunswick	339	350	391
Quebec	2,789	3,253	3,518
Ontario	4,985	5,623	5,759
Manitoba	695	697	765
Saskatchewan	475	524	542
Alberta	1,709	1,764	1,828
British Columbia	1,732	2,221	2,155
Yukon and N.W.T.	110	152	195
Canada	13,780	15,647	16,340

Source: Statistics Canada.
ᵖPreliminary; ᵉEstimated.

The Canadian industry

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

Table 1. Canada, production (shipments) sand and gravel by provinces, 1969-71

	1969		1970		1971^{p}	
	(short tons)	($)	(short tons)	($)	(short tons)	($)
Newfoundland	3,957,022	3,742,412	4,335,000	4,474,000	6,100,000	6,000,000
Prince Edward Island	902,218	451,500	827,000	640,000	850,000	650,000
Nova Scotia	9,167,109	8,913,502	7,187,000	6,623,000	7,700,000	7,000,000
New Brunswick	3,993,628	1,391,158	6,883,000	1,969,000	4,700,000	1,500,000
Quebec	41,500,000	17,222,000	36,795,000	17,503,000	37,000,000	17,500,000
Ontario	82,657,386	46,245,525	82,877,000	54,419,000	84,500,000	55,500,000
Manitoba	8,142,268	5,053,794	14,930,000	9,406,000	14,000,000	9,000,000
Saskatchewan	7,673,225	3,369,132	8,963,000	4,279,000	8,200,000	4,000,000
Alberta	14,903,937	10,530,148	16,042,000	13,000,000	16,400,000	13,300,000
British Columbia	28,684,705	25,239,975	23,817,000	21,245,000	22,000,000	19,800,000
Canada	201,581,498	122,159,146	202,656,000	133,558,000	201,450,000	134,250,000

Source: Statistics Canada. ^{p}Preliminary.

Table 2. Canada, production (shipments) sand and gravel by uses, 1969-70

	1969		1970	
	(short tons)	($)	(short tons)	($)
Sand and gravel				
Fill	14,433,573	5,543,649	17,084,207	8,217,620
Backfill for mines	1,281,412	526,917	1,444,886	624,921
Roads (road bed, surface)	75,038,464	28,842,047	86,355,654	40,370,579
Concrete aggregate				
sand	13,249,370	11,286,845	12,476,168	11,944,513
gravel	4,790,541	4,492,021	3,661,978	4,317,087
Asphalt aggregate				
sand	2,691,917	2,090,912	2,257,379	1,665,993
gravel	1,445,056	977,337	1,140,062	975,494
Railroad ballast	1,638,942	562,848	970,768	519,481
Mortar sand	1,866,398	1,822,932	1,698,235	1,934,231
Other uses	979,101	1,574,481	845,209	788,169
Total	117,414,774	57,719,989	127,934,546	71,358,088
Crushed gravel				
Backfill for mines	–	–	–	–
Roads (road bed, surface)	71,897,792	52,107,585	45,714,364	35,127,546
Concrete aggregate	5,741,182	5,680,331	4,635,180	5,521,753
Asphalt aggregate	2,476,872	2,596,054	3,566,127	4,037,351
Railroad ballast	1,548,603	1,413,714	2,119,939	1,947,830
Other uses	2,502,275	2,641,473	18,658,844	15,565,432
Total	84,166,724	64,439,157	74,721,454	62,199,912
Total sand and gravel	201,581,498	122,159,146	202,656,000	133,558,000

Source: Statistics Canada. – Nil.

not only tended to overrun operating pits and quarries but has extended at times over areas containing mineral deposits, precluding 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 determine and regulate the optimum utilization of land. Industry must locate to minimize the environmental effects of plant 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 such activity.

In Ontario, regulations outlining requirements for licensing gravel pits and quarries, as well as standards for the rehabilitation of pit and quarry lands, were approved by the Provincial Government on December 22, 1971. Forty-two townships along the Niagara Escarpment were designated initially as areas over which the Pit and Quarries Act would apply. An additional 17 townships in the Toronto, London and Ottawa areas were designated in early 1972.

Besides 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.

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 too strongly emphasized.

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

Table 3. Production (shipments) sand and gravel, by uses, by area, 1969-70

		Atlantic Prov.	Quebec	Ontario	Western Prov.	Canada
		(st)	(st)	(st)	(st)	(st)
Fill	1969	244,788	1,255,605	7,125,675	5,807,505	14,433,573
	1970	92,990	1,561,549	7,374,756	8,054,912	17,084,207
Backfill for mines	1969	190,050	2,474	1,067,748	21,140	1,281,412
	1970	171,000	500	1,249,086	24,300	1,444,886
Roads (road bed, surface)	1969	14,995,269	35,106,330	57,582,405	39,252,252	146,936,256
	1970	15,445,095	30,323,915	51,346,526	34,954,482	132,070,018
Concrete aggregate	1969	1,116,192	3,569,195	10,308,408	8,787,298	23,781,093
	1970	1,245,965	2,847,271	10,067,741	6,612,349	20,773,326
Asphalt aggregate	1969	1,161,171	945,622	2,792,411	1,714,641	6,613,845
	1970	1,223,549	993,913	2,240,612	2,505,494	6,963,568
Railroad ballast	1969	207,924	267,711	828,864	1,883,046	3,187,545
	1970	504,564	285,485	299,561	2,001,097	3,090,707
Mortar sand	1969	21,342	195,672	1,422,331	227,053	1,866,398
	1970	38,009	140,950	1,225,576	293,700	1,698,235
Other uses	1969	83,241	157,391	1,529,544	1,711,200	3,481,376
	1970	510,828	641,417	9,073,142	9,305,666	19,531,053
Total	1969	18,019,977	41,500,000	82,657,386	59,404,135	201,581,498
	1970	19,232,000	36,795,000	82,877,000	63,752,000	202,656,000

Source: Statistics Canada.

Table 4. Canada, exports and imports of sand and gravel, 1969-71

	1969		1970		1971	
	(short tons)	($)	(short tons)	($)	(short tons)	($)
Exports						
Sand and gravel						
United States	457,760	625,000	1,239,692	1,936,000	774,639	1,089,000
South Africa	–	–	–	–	54	3,000
West Germany	55	11,000	440	2,000	22	1,000
Guyana	10	1,000	15	1,000	–	–
Other countries	93	3,000	45	1,000	11	1,000
Total	457,918	640,000	1,240,192	1,940,000	774,726	1,094,000
Imports						
Sand and gravel, not elsewhere stated						
United States	859,898	737,000	502,425	537,000	675,275	785,000
Netherlands	–	–	314	1,000	–	–
Total	859,898	737,000	502,739	538,000	675,275	785,000

Source: Statistics Canada. – Nil.

capita by 1980 – in 1967 the Toronto-Hamilton area consumed about 15.4 tons per person. This could make outlying deposits not only attractive but necessary and could also encourage development of underwater deposits. It is not completely impossible that areas of concentrated population, such as the eastern seaboard of the United States, where reserves of aggregates are already becoming depleted, will have to import their requirements perhaps 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 course 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 acceptability of aggregates for certain applications. Particle size distribution of aggregates, as assessed by grading tests or sieve analyses, affects the uniformity and workability of a concrete mix as well as the strenght 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, schools, etc. Heavy construction awards can be used to provide an estimate of the quantity of aggregate required for given projects, over given periods of time.

Table 5. Canada, sand and gravel, production (shipments) and trade, 1961-71

	Production	Imports	Exports
1961	170,750,947	537,972	389,495
1962	181,245,762	838,894	354,107
1963	189,570,503	561,965	356,124
1964	193,791,358	593,455	461,464
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	201,450,000	675,275	774,726

Source: Statistics Canada.

Movement of sand and gravel from the pit or quarry is normally by truck, and as quarry sites are being forced to locate farther from the consuming areas, costs of 5 cents a ton-mile and more can become so large in total that alternative sources are continually being sought. It is only rarely that a unit-train concept would be applicable because of the wide physical distribution of consumers within an area and because optimum utilization of such facilities would be difficult to attain. Bulk "hook and haul" trains are used in the Toronto area to haul minimum loads of 4,000 tons at negotiated freight rates.

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 the sea bed. The use of huge pumps and specially equipped ships to draw gravel from the sea floor and deposit it in attendant barges is already being tested.

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 consideration and higher labour costs.

Selenium and Tellurium

ROBERT J. SHANK

SELENIUM

Selenium occurs sparsely disseminated throughout the earth's crust in a wide variety of selenium-bearing minerals. These minerals do not occur in sufficient concentration to allow commercial exploitation for their selenium content alone and production is derived mainly as a byproduct of copper refining.

The output of selenium as metal or compounds occurs in the copper-refining nations, including the United States, Canada, Japan, Sweden, Zambia, Belgium and Luxembourg, Australia, Finland, Mexico and Peru. There is also production in the U.S.S.R. and other communist countries. Selenium supply is dependent upon copper production and, because of this, it is difficult to adjust supply to demand. There is limited recovery of selenium from secondary sources. The drop in world production that has been reported in both 1970 and 1971 can be attributed primarily to lower output in the United States, with the 1971 drop due to strikes that occurred in the United States copper industry that year.

Production of selenium in all forms in Canada in 1971 amounted to 719,000 pounds valued at $6,531,000, compared with 663,336 pounds valued at $5,704,690 in 1970. Refined production from anode slimes and stockpiled material was 885,931 pounds, up from 854,452 pounds in 1970. Domestic consumption amounted to 15,686 pounds, virtually unchanged from the 15,730 pounds used in 1970. The remainder of the refined production was exported, principally to the United States and Britain.

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 and the Murdochville smelter of Gaspe Copper Mines, Limited, both in Quebec, and blister 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 (99.9 per cent Se), and a great variety of metallic and organic selenium compounds. Annual capacity is 450,000 pounds of selenium in metals and salts. Although the capacity of the copper refinery is to be expanded by 22 per cent in 1972, no announcement has been made of any planned changes to selenium capacity.

The 270,000-pound-a-year selenium recovery plant of The International Nickel Company of Canada, Limited 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%).

Consumption and uses

Selenium is used in the glass, rubber, chemical, plastics, steel, and electronics industries and for xerography. Development of the dry-plate rectifier during World War II brought about a sharp increase in the demand for selenium that persisted into the postwar period. Selenium prices rose to such an extent that substitution in all applications took place and subsequently the demand and price for selenium declined. Stable supply and the efforts of the Selenium and Tellurium Development Association have gradually developed new markets and recaptured some of the lost markets. One of the fastest growing uses for selenium is in the plastics industry where selenium and cadmium sulphide are used to produce orange to maroon colours which are stable at high temperatures. These pigments are also used in the ceramic and paint industries and as colouring inks for printing on glass containers.

Table 1. Canada, selenium production, exports and consumption, 1970-71

	1970		1971p	
	(pounds)	($)	(pounds)	($)
Production				
All forms[1]				
Quebec	413,084	3,552,522	550,000	5,001,000
Ontario	131,506	1,130,952	29,000	1,163,000
Manitoba	75,840	652,224	32,000	296,000
Saskatchewan	42,906	368,992	8,000	71,000
Total	663,336	5,704,690	719,000	6,531,000
Refined[2]	854,452	..	885,931	..
Exports (metal)				
United States	450,400	4,416,000	334,600	3,511,000
Britain	203,900	1,603,000	225,600	2,225,000
South Africa	3,000	37,000	4,000	38,000
Venezuela	1,300	8,000	2,000	18,000
Colombia	2,400	17,000	1,100	10,000
India	1,700	6,000	3,100	8,000
Other countries	23,400	173,000	1,100	9,000
Total	686,100	6,260,000	571,500	5,819,000
Consumption[3] (selenium content)	15,730	..	15,686	..

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 material and secondary sources. [3]Available data, consumption of selenium products (metal, metal powder, oxide), selenium content, as reported by consumers.
pPreliminary; .. Not available.

Table 2. Canada, selenium production, exports and consumption, 1962-71

	Production		Exports, Metals and Salts[3]	Consumption[4]
	All Forms[1]	Refined[2]		
	(pounds)			
1962	487,066	466,654	325,600	12,587
1963	468,772	462,385	445,700	12,424
1964	465,746	462,795	401,300	13,968
1965	512,077	514,595	451,200	15,888
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
1971p	718,000	885,931	571,500	15,686

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.
pPreliminary.

Selenium is used in glassmaking both as a decolorizer and as a colouring agent. Small quantities of selenium added to the glass batch help to neutralize the green colour imparted by iron in the glass sand. The brilliant red, ruby glass used in stop lights, signal lights, automotive taillights, marine equipment and decorative tableware, is produced by adding larger quantities of selenium to the glass batch. Selenium is also used in the production of glare-free glass. However, partial substitution of selenium by cerium oxide in the manufacture of glass was in evidence on a small scale during the year.

The chemical industry uses selenium as a catalyst in the manufacture of cortisone and nicotinic acid. Selenium and selenium compounds are used in the preparation of various proprietary medicines for the control of dermatitis in humans and animals, and for the correction of dietary deficiencies in animals. The addition of selenium to a proportion of 0.5 ppm as sodium selenite to certain animal feeds could open a fairly important market for selenium compounds. In this regard it is interesting to note that Canadian Copper Refiners Limited is the only selenium producer in North America that manufactures sodium selenite.

Table 3. Noncommunist world production of selenium, 1969-71

	1969	1970	1971[e]
	(pounds)		
United States	1,229,000	1,005,000	750,000
Canada	599,000	663,000	718,000
Japan	435,000	449,000	450,000
Sweden	176,000	170,000	170,000
Zambia[e]	57,000	..	..
Belgium and Luxembourg	55,000	53,000	55,000
Other countries	96,000	96,000	125,000
Total	2,647,000	2,436,000	2,268,000

Sources: For Canada, Statistics Canada. For other countries, U.S. Bureau of Mines *Minerals Yearbook, 1969* and U.S. Commodity Data Summaries, January 1972.
[e]Estimated; .. Not available.

Finely ground metallic selenium and selenium diethyldithiocarbamate (selenac) are used in natural and synthetic rubber to increase the rate of vulcanization and to improve the aging and mechanical properties of sulphurless and low-sulphur rubber stocks. Selenac acts as an accelerator in butyl rubber.

Selenium, in proportions from 0.20 to 0.35 per cent improves the porosity of stainless steel castings. Ferroselenium (55 to 57 per cent Se) is added to stainless and lead-recarburized steels to improve their machinability and other properties.

Table 4. Canada, industrial use of selenium, 1969-71

	1969	1970	1971
	(pounds of contained selenium)		
By end-use			
Glass	12,600	12,000	11,200
Other[1]	2,900	3,700	4,500
Total	15,500	15,700	15,700

Source: Statistics Canada, Consumers' Reports.
[1] Electronics, rubber, steel, pharmaceuticals.

Outlook

There is hope that the growth in selenium consumption will return in the near future. Whether or not this will occur, and how rapidly, depends in large measure on the discovery of new uses for the metal or its compounds. Supply will continue to be limited to that which is available from copper output as well as that available from scrap sources.

Prices

According to *Metals Week*, United States selenium prices from January 4 to December 20, 1971, were $9 per pound for commercial-grade and $11.50 per pound for high-purity.

Tariffs

Canada

Item No.		British Preferential	Most Favoured Nation	General
92804-4	Selenium metal	5%	10%	15%

United States

Item No.		On and After January 1 1970	1971	1972
		(%)	(%)	(%)
632.40	Selenium metal, unwrought, other than alloys and waste and scrap	free	free	free
632.84	Selenium metal alloys, unwrought	12.5	10.5	9
633.00	Selenium metals, wrought			
420.50	Selenium dioxide	free	free	free
420.52	Selenium salts			
420.60	Selenium compounds, other	7	6	5

Sources: The Custom Tariff and Amendments, Department of National Revenue, Customs and Excise Division. Tariff Schedules of the United States Annotated 1972, T.C. Publication 452.

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.

Canadian production of tellurium in all forms in 1971 amounted to 24,000 pounds valued at $148,000. Refined production partly from imported materials was 43,558 pounds. Comparable statistics for 1970 were 58,333 pounds in all forms valued at $365,748 and 64,634 pounds of refined production. The 1971 statistics for production in all forms may not be representative of mine output because of difficulties with determining the origin and quantity of production. Refined production in 1971 was lower, partly because tellurium refining at Canadian Copper Refiners was temporarily suspended, to install additional pollution control equipment.

Consumption and uses

Tellurium is recovered from the same sources as selenium and therefore its production, which limits its growth of consumption, is governed by the same factors. Low production, unpleasant odour, and toxicity of tellurium continue to inhibit its use in industry. When it is absorbed into the body by direct contact or inhalation, tellurium has an adverse physiological effect resulting in a strong garlic odour imparted to the breath and perspiration.

The metallurgical industry consumes a large part of the tellurium produced as a carbide-stabilizing agent in the production of white cast iron, and as an additive to low-carbon steel, free machining stainless steel, and cast iron.

Tellurium powder is added to molten iron to control the depth of chill in grey-iron castings. A 99.5 per cent copper and 0.5 per cent tellurium alloy is used in the manufacture of welding tips and in radio and communications equipment because it can be extensively cold-worked and has good hot-working properties and high thermal and electric conductivity. Up to 0.1 per cent tellurium in lead forms a corrosion-resistant alloy used to sheath marine cables and to line tanks subject to chemical corrosion.

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. Although these devices have received increased attention, the amount of tellurium used in these applications has not risen as fast as was expected.

Rubber containing tellurium is resistant to heat and abrasion. Its principal use is for the jacketing of portable electric cables used in mining, dredging, welding, etc. Tellurium is added to sulphurless or low-sulphur stocks of natural and synthetic rubber in powder form or as tellurium diethyldithiocarbamate to improve the rubber's aging and mechanical properties. The diethyldithiocarbamate compound also helps to reduce the porosity of thick rubber sections and, in combinations with mercaptobenzothiazol, is one of the fastest known accelerators used in making butyl rubber.

Table 5. Canada, tellerium production and consumption, 1970-71

	1970		1971p	
	(pounds)	($)	(pounds)	($)
Production				
All forms[1]				
Quebec	43,197	270,845	12,000	72,000
Ontario	7,325	45,928	8,000	49,000
Manitoba	4,992	31,300	3,000	22,000
Saskatchewan	2,819	17,675	1,000	5,000
Total	58,333	365,748	24,000	148,000
Refined[2]	64,634		43,558	
Consumption[3] (refined)	880		1,178	

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.

Table 6. Canada, production and consumption of tellurium, 1962-71

	Production		Consumption
	All Forms[1]	Refined[2]	Refined[3]
	(pounds)		
1962	58,725	57,630	4,306
1963	76,842	79,640	1,853
1964	77,782	80,255	1,473
1965	69,794	71,730	1,870
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[r]	880
1971[p]	24,000	43,558	1,178

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; [r]Revised.

Table 7. Noncommunist world production of tellurium

	1969	1970	1971[e]
	(pounds)		
United States	234,000	158,000	150,000
Canada	62,000	58,000	24,000
Japan	51,000	78,000	80,000
Peru	38,000	62,000	60,000
Total	385,000	356,000	314,000

Sources: For Canada, Statistics Canada. For other countries, U.S. Bureau of Mines *Minerals Yearbook, 1969;* U.S. Bureau of Mines Commodity Data Summaries, January 1972.
[e]Estimated.

Price

According to *Metals Week,* the United States tellurium price throughout 1971 was $6 per pound for powder in 100-pound lots and for slab in 150-pound lots.

Tariffs

Canada

Item No.		British Preferential	Most Favoured Nation	General
92804-5	Tellurium metal	5%	10%	15%

United States

Item No.		On and After January 1 1970	1971	1972
		(%)	(%)	(%)
632.48	Tellurium metal, unwrought, other than alloys, and waste and scrap (duty on waste and scrap suspended to June 30, 1973)	5.5	4.5	4
632.84 633.00	Tellurium metal alloys, unwrought Tellurium metal, wrought	12.5	10.5	9
421.90 427.12	Tellurium compounds Tellurium salts	7	6	5

Sources: The Custom Tariff and Amendments, Department of National Revenue, Custom and Excise Division. Tariff Schedule of the United States Annotated, 1972, TC Publication 452.

Silica

G.H.K. PEARSE

Silica (SiO_2) occurs as the mineral quartz in a variety of rocks and unconsolidated sediments. Although the mineral is one of the most abundant, 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 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 pipe, cement blocks and bricks.

Production of silica in Canada fell from the record 3.2 million tons in 1970 to 2.5 million tons in 1971. The decrease is attributable to strikes in the principal consuming industries, technical difficulties experienced at Indusmin Limited's Midland, Ontario operation and cutbacks in smelter output, primarily of nickel but also of copper and lead, with the consequent reduction in requirements for metallurgical flux.

Most of the silica produced in Canada is low-value lump silica and silica sand consumed as a 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. The Winnipeg Supply and Fuel Company, Limited quarries high-grade silica sandstone on Black Island in Lake Winnipeg and processes the material at the company's plant located at Selkirk, Manitoba.

Canada imports high-grade silica sand for use in glass manufacture along with substantial quantities of sand suitable for foundry castings. In 1971, imports increased more than 100,000 tons over 1970 to reach 1.4 million tons valued at $5.6 million. Virtually all imports are from the United States. In 1971, some 20,000 tons of silica were imported from Belgium to supply Ahlstrom Canada Limited's glass container plant at Scoudouc, New Brunswick.

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 Electric Reduction Company of Canada, Ltd. (ERCO). ERCO's $40 million phosphorus plant requires about 100,000 tons of silica annually. Because of down time resulting from repeated breakage of electrodes, silica consumption was about half of normal operating requirements in 1971.

Quebec. Indusmin Limited produces a wide variety of silica products at the company's mill near St-Canut, Quebec. In addition to quarrying Potsdam sandstone adjacent to the St-Canut mill, the company quarries a friable Precambrian quartzite from a deposit near St-Donat. Material from the St-Donat quarry is trucked about 50 miles to the St-Canut mill for processing. Products produced at St-Canut include: silica sand suitable for glass and silicon carbide manufacture; foundry sand; silica flour for use as a filler in tiles, asbestos pipe, cement 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.

Table 1. Canada, silica production and trade, 1970-71

	1970		1971p	
	(short tons)	($)	(short tons)	($)
Production, quartz and silica sand[1]				
By province				
Ontario	1,748,092	1,211,700	1,220,000	2,080,000
Quebec	694,782	3,885,644	670,000	1,503,000
Manitoba	507,705	1,131,440	450,000	650,000
British Columbia	25,727	140,000	30,000	140,000
Saskatchewan	169,744	170,000	80,000	80,000
Newfoundland	. .	170,000	. .	140,000
Nova Scotia	. .	101,953	. .	62,000
Total	3,238,037	6,810,737	2,526,000	4,655,000
By use				
Flux	2,321,376	1,968,030		
Ferrosilicon	208,059	940,816		
Glass	129,418	958,594		
Other uses[2]	579,184	2,943,297		
Total	3,238,037	6,810,737		
Imports				
Silica sand				
United States	1,279,677	5,232,000	1,396,495	5,513,000
Norway	5,071	76,000	3,578	60,000
Belgium-Luxembourg	9,033	23,000	20,205	51,000
Finland	2,756	6,000	–	–
Total	1,296,537	5,337,000	1,420,278	5,624,000
Silex and crystallized quartz				
United States	200	86,000	306	113,000
Netherlands	–	–	6	2,000
Brazil	–	–	. . . .	2,000
Other countries	5	42,000	–	–
Total	205	128,000	312	117,000
	(thousands)	($)	(thousands)	($)
Firebrick and similar shapes, silica				
United States	2,010	1,849,000	10,234	1,702,000
West Germany	10	13,000	7,773	1,649,000
Total	2,020	1,862,000	18,007	3,351,000
Exports				
Quartzite				
United States	64,945	149,000	100,646	212,000
Dominican Republic	–	–	18	. . .
Total	64,945	149,000	100,664	212,000

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; . . . . Less than one ton.

Table 2. Canada, silica production and trade, 1962-71

(short tons)

	Production	Imports			Exports	Consumption
	Quartz and Silica Sand[1]	Silica Sand	Silex or Crystallized Quartz	Flint and Ground Flintstone	Quartzite	Quartz and Silica Sand
1962	2,085,620	765,431	8,960	1,193	156,205	2,316,316
1963	1,836,612	787,157	11,887	1,812	47,437	2,413,498
1964	2,117,273	771,900	5,176	..	146,206	2,491,596
1965	2,433,685	834,780	5,104	..	111,533	3,156,466
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
1971p	2,526,000	1,420,278	312	..	100,664	..

Source: Statistics Canada.
[1] Includes silica to make silica brick.
p Preliminary; .. Not available.

Union Carbide Canada Mining Ltd. quarries quartzitic sandstone at Melocheville, Beauharnois County, for use in ferrosilicon manufacture at Beauharnois. Fines from this operation are used in foundry work, in cement manufacture and as a metallurgical flux.

E. Montpetit et Fils Ltée quarries sandstone in the Melocheville area for use by Chromium Mining & Smelting Corporation, Limited, in the manufacture of ferrosilicon, also in Beauharnois.

Baskatong Quartz Products produces lump silica and crushed quartz from a deposit on the southwestern shore of Lake Baskatong. The lump silica is used in the manufacture of silicon metal and to a lesser extent as grinding pebble. The crushed quartz is sold for use as exposed aggregate in decorative concrete.

Ontario. Indusmin Limited quarries a high-grade silica deposit on Badgeley Island in Georgian Bay. The deposit consists of very pure Lorraine quartzite of Precambrian age. A grinding and processing plant at Midland and a primary crushing plant at the deposit some 120 miles north of Midland across Georgian Bay came on stream during the first half of 1970. The Badgeley Island operation has a capacity of approximately 1 million tons per year of washed lump silica and fine material. The Midland plant can produce about 500,000 tons per 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.

Output at the Midland plant was restricted during the latter half of 1970 because of difficulties experienced with the classification circuit. During 1971, the grinding unit output was little better than 50 per cent of rated capacity. The unit was converted from a rod mill to a ball mill and although the efficiency of the plant was much improved during the year, it was anticipated that several months would be required to eliminate the problems.

Manitoba. The Winnipeg Supply and Fuel Company, Limited 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 Canada market. Silica sand suitable for the manufacture of glass containers is shipped to Alberta while 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.

British Columbia. Pacific Silica Limited ceased production of silica for ferrosilicon and silicon carbide in August 1968 at its deposit near Oliver, British Columbia. Stucco dash and roof chips are being produced from existing stockpiles.

Table 3. Canada, available statistics on consumption of silica by industries, 1969 and 1970

	1969	1970
	(short tons)	(short tons)
Smelter flux[1]	1,498,105	2,321,376
Glass manufacture (incl. glass fibre)	580,019	618,511
Foundry sand	818,796	824,227
Artificial abrasives	168,633	169,683
Ferrosilicon	173,580	188,947
Metallurgical use	88,292	82,868
Concrete products	28,985	22,920
Gypsum products	23,906	12,784
Asbestos products	36,525	36,247
Chemicals	19,876	24,423
Fertilizers, stock, poultry feed	20,950	26,321
Other	68,597	58,126
Total	3,526,264	4,386,433

Source: Statistics Canada for source data; classification by Mineral Resources Branch.
[1] Producers' shipments of quartz and silica for flux purposes.

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. Colour and texture are important. Some architects prefer a white, opaque quartz, while others prefer a shiny, translucent variety.

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, naturally 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 colourants. 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.

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 the crushing of friable sandstones 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 this 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 excape of gases 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 uses. 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 where there is insufficient silica in either the limestone or 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 finding increased use 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 piezoelectric properties is used in radio-frequency control, radar and other electronic devices. 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 2 inches in length and 1 inch or more in diameter. Most of the world's crystal requirement is met by natural crystal from Brazil; however, natural crystal is being replaced by excellent quality, synthetic crystal grown in the laboratory from quartz 'seed'. Artificial quartz crystals are delivered already oriented for the cutter. 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, where only a small demand exists. Domestic requirements are met largely by imports chiefly from Brazil and the United States. Quartz Crystals Mines Limited, Toronto, produced minor tonnages from an occurrence near Lyndhurst, Ontario, several years ago.

Outlook

Difficulties experienced at Indusmin's Midland plant and ERCO's phosphorous plant at Long Harbour are expected to be rectified during 1972. Silica-consuming industries have returned to normal after settlement of strikes which disrupted operations during the summer of 1971. Copper and lead smelting is expected to step up in 1972, recovering from 1971 production cutbacks. However, nickel output will be further reduced because of large inventories and the net increase on metallurgical silica consumption will be moderate. Total silica production in Canada is expected to reach 3 million tons in 1972.

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, 1970	35
	On and after Jan. 1, 1971	30
	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: The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa. Tariff Schedules of the United States Annotated (1972), T.C. Publication 452.

Silicon, Ferrosilicon and Silicon Carbide

D.D. BROWN

Canada's exports of ferrosilicon in 1971 were 51,827 tons valued at $8,503,000 compared with 49,984 tons valued at $8,248,000 in 1970. Imports of ferrosilicon were 10,380 tons valued at $2,679,000 in 1971 compared with 10,446 tons valued at $2,386,000 in 1970. Domestic ferrosilicon consumption was 55,728 tons in 1970 and 50,737 tons in 1969.

Published prices for ferrosilicon fob shipping point were unchanged during 1971 with the respective prices of 50, 75, 85 and 90 per cent Si ferrosilicon remaining at 16.0, 19.6, 20.3 and 20.3 cents a pound of contained silicon. The price of silicon metal fob shipping point did not change in 1971 and ranged from 21.5 to 25.4 cents a pound of contained silicon for different grades of silicon, depending on purity.

Silica (SiO_2) is the resource material from which silicon, ferrosilicon and silicon carbide are made; silica* is also an important raw material in making other industrial products and in many industrial in-plant processes.

Canada utilizes its silica resources principally in the mining of silica as quartz, quartzite, sandstone and silica sand, with beneficiation to sized and graded products. The products are used as metallurgical flux in the smelting of ores, in construction materials, in silica brick, in glass manufacture, in foundry and abrasive cleaning sands, in making ferrosilicon, or silicon carbide and other abrasive products, and in the manufacture of various silicon alloys.

Elemental silicon always occurs combined with oxygen as silica or in the form of silicates with other mineral elements. In these forms it accounts for about 59.8 per cent of the lithosphere. Silicon is second only to oxygen in order of abundance in the earth's crust.

*See Silica, No. 40 in 1971 Preprint Series of Mineral Reviews.

The mineral source of silica (SiO_2) for use in the metallurgical production of silicon and silicon alloys is usually a pure grade of quartz, quartzite, sandstone or silica sand containing about 98 per cent silica. Chemical specifications required for silicon and silicon alloys are: silica, 98 per cent; alumina, less than 1 per cent; iron oxide (Fe_2O_3) plus alumina, 1.5 per cent maximum; lime and magnesia, each less than 0.2 per cent. Phosphorus and arsenic should be absent since they are reduced in the electric furnace to calcium phosphide and calcium arsenide which form poisonous gases on contact with water.

Silicon is not a metal in the usual association of the term because it lacks ductility and electrical conductivity. It is solid, hard, and has a grey metallic lustre but is brittle rather than ductile and its conductivity is intermediate between that of conductors and insulators, exhibiting the property of semiconduction important to its electronic applications.

Silicon in the form of ferrosilicon alloys and metallurgical silicon metal is the most extensively used deoxidizer in the making of most grades of carbon and alloy steels. Ferrosilicon alloys are also important silicon alloying elements used to improve the strength, hardenability and oxidation resistance of a wide variety of steels.

Silicon alloys include ferrosilicon, silvery pig iron, silico-manganese, ferroaluminum-silicon, ferrochromium-silicon, ferromanganese-silicon, calcium-silicon, calcium-manganese-silicon, barium-silicon, ferrozirconium-silicon and zirconium-silicon, all of which are principally used in metallurgical industries. Ferrosilicon accounts for the largest tonnage of silicon alloys produced. Silicon is used in alloys of iron, aluminum and copper and in the preparation of silicones, silicates and other chemical products.

Table 1. Canada, ferrosilicon, silicon carbide and some other ferroalloys[1], exports and imports, 1970-71

	1970		1971	
	(short tons)	($)	(short tons)	($)
Exports				
Ferrosilicon				
Britain	26,281	4,336,000	28,139	4,282,000
Brazil	–	–	4,607	1,017,000
United States	13,527	1,551,000	8,953	800,000
U.S.S.R.	112	41,000	2,046	755,000
Netherlands	1,134	369,000	3,201	677,000
Australia	2,839	659,000	1,516	380,000
Angola	448	41,000	1,540	139,000
Other countries	5,643	1,287,000	1,825	453,000
Total	49,984	8,284,000	51,827	8,503,000
Silicon carbide, crude and grains				
United States	103,022	15,377,000	91,972	13,259,000
Brazil	–	–	1,102	188,000
Norway	2,953	595,000	603	130,000
Britain	–	–	182	16,000
Other countries	21	4,000	–	–
Total	105,996	15,976,000	93,859	13,593,000
Ferroalloys, nes				
Britain	640	2,139,000	465	1,247,000
United States	1,129	819,000	2,584	876,000
India	180	847,000	124	663,000
Netherlands	1,449	160,000	23	73,000
Australia	–	–	16	49,000
New Zealand	36	3,000	127	20,000
Other countries	661	282,000	59	17,000
Total	4,095	4,250,000	3,398	2,945,000
Imports				
Ferrosilicon				
United States	9,509	2,145,000	8,363	2,100,000
Norway	813	196,000	1,717	467,000
France	97	39,000	275	104,000
West Germany	–	–	19	6,000
Britain	5	2,000	6	2,000
South Africa	22	4,000	–	–
Total	10,446	2,386,000	10,380	2,679,000
Silicomanganese, incl. silico spiegel				
Norway	372	72,000	1,106	198,000
South Africa	387	67,000	560	72,000
United States	316	81,000	124	37,000
Total	1,075	220,000	1,790	307,000
Ferroalloys, nes				
United States	4,905	2,062,000	3,912	2,204,000
Britain	1,564	1,356,000	692	448,000
Brazil	71	224,000	108	289,000
France	717	294,000	596	235,000
West Germany	83	35,000	115	41,000
Total	7,340	3,971,000	5,423	3,217,000

Source: Statistics Canada.
[1]Important other ferroalloys are discussed in the mineral reviews of the respective metals, e.g., those of manganese, nickel, titanium, etc.
nes Not elsewhere specified; – Nil.

High-purity silicon crystal "doped" with traces of elements such as boron or phosphorus, is one of the most important semiconductors for use in transistors, diodes and rectifiers.

Silicon carbide or carborundum is an important abrasive and refractory.

Silicon in steel and iron

Silicon, introduced in the form of ferrosilicon into molten steel, is an effective and economical deoxidizer. In importance, silicon is second only to manganese in steelmaking as a ferroalloy additive; the latter deoxidizes steel and reduces its sulphur content. Silicon additions up to 1.5 per cent in standard alloy steels beneficially affect the mechanical properties by raising the tensile and yield strength and yet maintain the same ductile properties as the standard compositions. Probably the most important silicon-containing alloy steels are the electric (sheet) steels of 0.5 to 5 per cent silicon content. Electric steels have a small residual magnetism and low eddy current loss and therefore can be used in the manufacture of electric transformer cores, motors and generators. Steel for leaf springs and high-temperature alloy steels have a silicon content ranging from 0.5 to 2 per cent.

The silicon content of iron is second only to its carbon content for effectiveness in controlling the properties of iron castings. It is generally held to amounts between 0.5 and 3.0 per cent because machinability may be adversely affected above 2.0 per cent. As it is increased above 3.5 per cent it makes the iron matrix more and more brittle and forms silvery pig iron, an alloy which contains 6 to 20 per cent silicon. However, silicon additions from 1.5 to 4.5 per cent increase the resistance of iron to atmospheric and acid corrosion; additions greater than 10 per cent protect the metal from oxidation and chemical attack. Silicon is a necessary constituent of cast iron since it ensures that carbon does not chemically combine with iron but is present as graphite, and hence silicon is a graphite stabilizer. The distribution of graphite in cast iron has an important influence on its mechanical properties. Silicon is introduced into cast iron in the cupola charge as silvery pig iron or as ferrosilicon. Another popular additive is ferrosilicon in briquette form.

Among the elements used in steelmaking, silicon is a stronger deoxidant than chromium or manganese and is cheaper than aluminum or titanium. These facts and the need for a small silicon content in many types of steel make silicon, in the form of ferrosilicon, the deoxidizing agent most widely used in the steel industry.

Deoxidation of steel is one of the most important steps in its manufacture and its quality to a great extent depends on successful deoxidation. Steel can be broadly divided into three groups depending on the amount of gases, chiefly oxygen, dissolved in liquid steel. These are: rimming steel which is not, or is only slightly, deoxidized; semikilled steel, which is partly deoxidized; and killed steel, which is fully deoxidized. The amount of oxygen remaining in steel is largely a function of silicon, manganese and carbon content. The silicon content of rimming steel is nil to 0.05 per cent, of semikilled steel, up to 0.1 per cent, and of killed steel, 0.1 to 0.5 per cent.

Silicon metal

Silicon metal having a purity of approximately 98 per cent silicon is obtained by the carbon reduction of high-purity silica rock as quartz or quartzite in the submerged arc smelting furnace. The major use of silicon metal is in the manufacture of aluminum alloys by die-casting operations. It is alloyed in amounts ranging up to 12 per cent with aluminum. In these alloys silicon improves such casting qualities as fluidity. It reduces shrinkage and hot-cracking, and it increases corrosion resistance, hardness and tensile strength. Silicon increases the ability of aluminum to withstand impact and friction. In copper, silicon metal is added as an alloying agent to produce silicon bronzes.

Because of its unique chemical characteristics, silicon metal is a basic raw material in the production of silicone-type lubricants, hydraulic fluids, resins, plastics, enamels and rubbers. Purified silicon metal possesses semiconductive properties suitable for use in miniaturized electronic circuits.

Ferrosilicon

Ferrosilicon contains from 6 to 95 per cent silicon. Most of this alloy with up to 12 per cent silicon is made in blast furnaces. All silicon ferroalloys with over 15 per cent silicon are produced in submerged-arc

Table 2. Ferrosilicon consumption and steel production in Canada, 1961-71

	Crude Steel Production	Ferrosilicon Consumption
	(st)	(lb/ton steel)
1961	6,488,000	3.5
1962	7,173,000	3.6
1963	8,190,000	3.6
1964	9,128,000	3.8
1965	10,068,000	4.2
1966	10,020,000	4.4
1967	9,694,000	3.8
1968	11,251,000	4.2
1969	10,307,000	4.8^r
1970	12,346,000	4.5
1971^p	12,170,000	. .

Source: Statistics Canada.
^{p}Preliminary; . . Not available; ^{r}Revised.

Table 3. Canada, consumption, exports and imports of ferrosilicon, 1962-71

	Consumption	Exports		Imports	
	(st)	(st)	($)	(st)	($)
1962	20,106	43,249	4,184,149	6,119	1,354,297
1963	24,182	36,736	3,705,201	3,826	1,159,414
1964	27,275	45,987	4,525,306	3,433	892,938
1965	33,811	46,424	4,706,724	6,260	1,799,546
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	. .	51,827	8,503,000	10,380	2,679,000

Source: Statistics Canada.
. . Not available.

Table 4. Canada, ferrosilicon consumption in the steel industry, 1961-1970

	High Silicon (over 55% Si)	Medium Silicon	Low Silicon (under 45% Si)	Sil-X	Total
	(st)	(st)	(st)	(st)	(st)
1961	1,311	9,783	189	57	11,340
1962	1,691	11,222	44	54	13,011
1963	2,009	12,587	65	62	14,725
1964	1,987	15,294	159	71	17,511
1965	3,326	17,774	205	94	21,399
1966	3,914	17,828	130	88	21,960
1967	3,585	14,467	234	9	18,295
1968	5,783	15,788	1,841	13	23,425
1969	7,173	15,454	1,847	11	24,485
1970	. .	. .	. .	. .	. .

Source: Statistics Canada annual report, Iron and Steel Mills.
. . Not available at time of publication.

electric furnaces. In blast furnaces, ferrosilicon is made by carbon reduction of silica rock and iron from iron ore in the presence of coke and limestone. In electric furnaces, the higher silicon grades are made by melting low-alloy steel scrap, as a source of iron, and reducing high-purity silica rock with a high-carbon material such as coal or charcoal.

Silvery pig iron, containing 5-20 per cent silicon, is used primarily as steel furnace "block", which is added in lump form for the initial deoxidation of steel. The lower grades of ferrosilicon (below 25 per cent Si) are not suitable for ladle addition because the large amount required would have an excessive chilling effect on steel; they are used as bath additions and are available in the form of pigs or coarse lumps. The most extensively used silicon alloy is 50 per cent ferrosilicon. It is used as a deoxidizer and alloying agent in the production of killed and semikilled steels. The 65 per cent ferrosilicon is used as a ladle addition when the endothermic effect of the lower grade cannot be tolerated. The 75 and 90 per cent ferrosilicon grades are used for high-alloy steels requiring large additions of silicon. The 85 per cent grade is used mainly by cast-iron foundries. Sil-X is a briquetted mixture of ferrosilicon and sodium nitrate which is highly exothermic when added to the steel bath.

The decline of open hearth steelmaking and rise of electric furnace steel production has resulted in a decline of silvery pig iron production with an attendant rise in ferrosilicon production.

The low-aluminum grade (0.40 per cent Al maximum) 50 per cent ferrosilicon is used as a source of silicon for electrical steels containing less than 2 per cent silicon.

Typical analyses of some of the common silicon ferroalloys are given in Table 6.

Table 5. Canada, ferrosilicon production,[1] 1963-70

	Ferrous Industry	Other Industries[2]	Total
	(st)	(st)	(st)
1963	71,332	13,263	84,595
1964	86,548	12,660	99,208
1965	81,114	14,907	96,021
1966	76,943	16,547	93,490
1967	82,354	12,609	94,963
1968	82,710	10,392	93,102
1969	104,890	12,599	117,489
1970	. .	8,914	. .

Source: Statistics Canada.
[1]Producers' shipments. [2]Principally abrasives industry byproducts.
. . Not available at time of publication.

Table 6. Common silicon addition agents

Silicon Ferroalloy	Typical Composition					
	C	Si	Fe	P max	S max	Mg
(% ferrosilicon)	(weight per cent)					
10	2.00	10.50	86.00	0.15	0.06	
15	0.80	15.00	81.00	0.15	0.06	
22		22.00	78.00	0.06	0.04	
50	0.05	49.00	48.00	0.05	0.04	
75	0.05	75.00	21.50	0.05	0.04	
90	0.05	94.00	4.00	0.05	0.04	
Magnesium-ferrosilicon		44.00	50.30			9.00

Source: *Electric Furnace Steelmaking,* Vol. 1, Design, Operation and Practice, AIME, 1962.

Silicon carbide

The prime importance of silicon carbide (SiC) is its use as an abrasive. Silicon carbide, or carborundum, is harder and sharper-grained but more brittle than the other major manufactured abrasive, aluminum oxide (manufactured corundum). The hardness of silicon carbide is 9.5 to 9.75 in Moh's scale, being between diamond (10) and corundum (9). Silicon carbide grains fracture readily and maintain sharp cutting edges. Sized, graded grains of silicon carbide are used for lapping and grinding and to form abrasive pastes or sticks. Silicon carbide is bonded with other materials to form wheels and shapes that are then baked and cured and it is incorporated with paper or cloth to form abrasive sheets, discs, or belts. The hardness and wear resistance of silicon carbide is important to its use in brake linings, floor or stair treads, terrazzo tile, and in some deck paints.

General chemical and physical stability, low coefficient of expansion, and high thermal conductivity make silicon carbide an important material for refractory use. Suitable silicon carbide refractory shapes are used in boiler furnace walls, muffles and kilns.

Electric heating elements are made by extruding a mixture of silicon carbide grain in a temporary binder, heating to set the mixture, then firing in an electric furnace to burn out the binder and recrystallize the grain. Such heating elements are used in furnaces operating up to about 1,600°C, as a source of infrared radiation for drying operations, and as a light source for mineral determinations.

Silicon carbide is also used in ferrous metallurgy. When added to molten steel the vigorous exothermic reaction results in a hotter melt; the silicon carbide decomposes to deoxidize and cleanse the metal and to promote fluidity. It produces a more random dispersion of graphite flakes to give a more machinable product. It may be added as granules to molten steel or as briquettes to the cupola charge in producing cast iron.

Silicon carbide has a wide range of uses that include high-density self-bonded shapes for mould liners, spray nozzles and orifices for handling hot gases or abrasive and corrosive materials. It may be used as pebbles for pebble-bed heaters or fluidized bed reactors, as in gas chlorination apparatus.

The semiconducting property of silicon carbide has made it useful in thermistors and varistors, and in diodes, rectifiers and transistors for use at temperatures above the range of silicon or germanium.

Silicon carbide has a relatively low neutron absorption cross section and good resistance to

Table 7. Canada, manufacturers' shipments of silicon carbide, 1960-70

	Crude Silicon Carbide	
	(short tons)	($)
1960	84,611	13,026,000
1961	79,188	12,478,000
1962	65,853	10,233,000
1963	78,370	11,040,000
1964	85,433	11,398,000
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

Source: Statistics Canada.

Table 8. Canada, exports of silicon carbide, 1961-71

	(short tons)	($)
1961	84,326	12,795,554
1962	62,765	9,343,177
1963	72,905	9,855,821
1964	81,058	10,625,294
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

Source: Statistics Canada.

radiation damage, making it useful in some nuclear reactor applications.

Silicon carbide is made by the intense heating of a mixture of high-grade silica sand and crushed coke with small proportions of sawdust and common salt in electric resistance furnaces. During the loading of the charge a core of graphite is placed at the centre of the load, leading from the electrode at one end to that at the other end of the trough-shaped furnace. When a voltage is applied the resistance of the core causes heat to be generated and the temperature rises at the core to a maximum of about 2,595°C. The production rate is about 0.35 pound of product per kilowatt hour and the basic chemical reaction is: $SiO_2 + 3C \rightarrow 2\,CO + SiC$. Sawdust increases the porosity of the charge to aid the release of carbon monoxide and common salt reacts with iron and other impurities to produce volatile chlorides. After 36 hours the current is switched off and the furnace is allowed to cool for 36 to 48 hours. The silicon carbide is removed from an outer shell of unconverted or partly converted material. The masses of silicon carbide crystals are broken, crushed, cleaned by acid or alkali treatment, washed and dried. The crude grain is further crushed, size-classified and magnetically treated to remove any iron contamination from the crushing equipment.

Producers

A listing of silicon and ferrosilicon producers in Canada is given in Table 9. In addition to these producers there are a number of abrasive manufacturers which produce silicon carbide and low-grade ferrosilicon containing 10 to 16 per cent silicon (Si). These silicon carbide manufacturers include Canadian Carborundum Company, Limited; The Exolon Company of Canada, Ltd.; Lionite Abrasives, Limited; and Norton Company.

Other silicon alloys

Production of miscellaneous silicon alloys increased in recent years because of changing steelmaking practice and the demand for high-performance iron and steel products. Specialized ferrosilicon additives contain, in addition to iron and silicon, one or more of the following elements: aluminum, barium, boron, calcium, cerium, chromium, magnesium, manganese, titanium and zirconium. Some of the more important commercial grades of silicon-bearing alloys are:

Alloy Names	*Alloy Composition*
	(%)
Calcium-silicon	30-33Ca, 60-65Si, 3Fe max.
Calcium-manganese-silicon	16-20Ca, 14-18Mn, 53-59Si
Ferrochromium-silicon	35-50Cr, 30-50Si, 0.05-1.25C
Magnesium-ferrosilicon	44-48Si, 5-50Mg, 1.0-1.5Ca, 0.5Ce
Silico-manganese	50-68Mn, 12.5-27Si, 1.5-3C, balance Fe
Simanal	20Si, 20Mn, 20Al, balance Fe
Silicon-zirconium (SMZ)	60-65Si, 5-7Zr, 5-7Mn, 3-4Ca, balance Fe

Boron silicides (BSi), combined with ferrosilicon, are made by carbon reduction of oxides in an electric furnace. Very small amounts of boron are needed to increase the hardness of steel and may be used to replace, to some extent, larger amounts of more expensive ferroalloys.

Calcium-silicon and calcium-manganese-silicon are efficient deoxidizers and degassifiers of steel. They prevent the formation of alumina-type inclusions which are a major source of fatigue in highly stressed alloy steels, and promote the random distribution of brittle sulphides in steel. The manganese assists in obtaining a pearlitic matrix and improves strength and machinability of castings. These additives are made by carbon reduction of lime, silica and various manganese-bearing materials in submerged-arc electric furnaces.

Ferrochromium-silicon alloys are made in electric furnaces in the same way as ferrosilicon. The higher carbon grades, with 3 to 8 per cent C, are used in low-alloy steels. The silicon content makes them readily soluble in iron and reduces metal oxides while the chromium dissolves in the metal. The low carbon grades, with 0.01 to 2 per cent C, are used in producing stainless, and heat and corrosion resistant steels.

Table 9. Canada, silicon and ferrosilicon producers

Company	Location of Plant	Product	Capacity
			(net[1] tons/year)
Chromium Mining & Smelting Corporation, Limited	Beauharnois, Que	Ferrosilicon, 50, 75, 80 and 85% grades, silico-manganese	50,000
Union Carbide Canada Limited, Metals and Carbon Division	Beauharnois, Que.	Ferrosilicon, 45, 50, 75, 80 and 90% grades, silicon metal	65,000-75,000
	Welland, Ont.	Ferrosilicon, silico-manganese	75,000-100,000
Chicoutimi Silicon Ltd.	Chicoutimi, Que.	Ferrosilicon	25,000

[1] Gross weight.

Magnesium silicides in alloy combinations with iron, manganese, copper, nickel and rare-earth elements are used in the production of ductile or nodular cast iron. The more commonly used of such alloys are: nickel-iron-silicon-magnesium. iron-silicon-magnesium, and iron-silicon-magnesium-rare earths. The rare-earth content usually ranges from 0.1 to 1.5 per cent, and the magnesium content from 5 to 10 per cent but for special uses it may be 50 per cent or more. One of the better known uses of nodular iron is in the making of automotive crankshafts where uniform, machinable castings are required.

Silicon-aluminum alloys with 10 to 50 per cent silicon, 10 to 20 per cent aluminum and the remainder one or more of iron, manganese, chromium or zirconium are made by carbon reduction of the oxides in electric furnaces. These alloys are used to control the grain size of steel and reduce the harmful effects of nitrogen.

Manganese silicides containing varying amounts of iron and carbon are made by carbon reduction of manganese ore or mangenese-bearing slag with silica in the electric furnace. Silico-manganese is suitable for adding manganese to low-carbon steel; it also acts as a deoxidizer and cleanser of the steel.

Titanium silicide may be made by adding titanium scrap to molten silicon metal. The use of titanium silicide represents an economical way of introducing titanium to molten steel in cases where silicon is needed for slag reduction.

Vanadium silicides made by reduction of vanadium ores or concentrates in the electric furnace can be similarly used as an economical means of adding vanadium to steel.

Silicon-zirconium alloys containing 30 to 65 per cent silicon and 5 to 40 per cent zirconium are made by carbon reduction of the oxides in the electric furnace. These alloys are used as deoxidizers and scavengers. Zirconium combines readily with excess oxygen, nitrogen and sulphur to form inclusions that float out of the molten bath or are rendered least harmful.

Prices

Prices published by Metals Week in December 1970 and 1971

	1970 and 1971
	(U.S.¢)
Ferrosilicon, pound contained silicon fob shipping point, freight equalized to nearest main producer, carload lots, lump bulk	
High-purity (%Si)	
75	19.6
85	20.3
90	20.3
Regular 50	16.0
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	25.4
0.50 0.07	23.7
1.00 0.07	21.5
Magnesium ferrosilicon 44/48 Si	
(% Mg) (% Ce)	
9	1970, 29.95; 1971, 23.95
9 0.5	26.25
5 0.5	19.80
35-40 zirconium silicon	33.75

Prices published by American Metal Market in December 1970 and 1971

	1970	1971
	(U.S.¢)	(U.S.¢)
SMZ alloy: 60-65% Si, 5-7% Mn, 5-7% Zr, 15-ton lots, per pound of alloy	22.3	23.0
Calcium-silicon and calsibar alloy, fob producer, 15-ton lots, per pound	24.0	24.75
Electric furnace silvery pig iron, fob Niagara Falls	(U.S.$)	(U.S.$)
16% Si, per ton	90.50	90.00
22% Si, per gross ton	105.74	106.00

Tariffs

Canada

Item No.		British Preferential	Most Favoured Nation	General
			(¢)	(¢)
	Ferrosilicon, an alloy of iron and silicon, effective June 4, 1969			
37503-1	containing 8% or more by weight of silicon and less than 60% per pound, or fraction thereof	free	free	1.75
37504-1	containing 60% or more by weight of silicon and less than 90% per pound, or fraction thereof, on the silicon contained therein	free	0.75	2.75
37505-1	containing 90% or more by weight of silicon per pound, or fraction thereof, on the silicon contained therein	free	2½	5½

United States

Item No.		On and After Jan. 1, 1971	On and After Jan. 1, 1972
		(¢)	(¢)
	Ferrosilicon, per pound Si content		
607.50	containing over 8% but not over 60% by weight of silicon	0.1	free
607.51	containing over 60% but not over 80% by weight of silicon	0.55	0.5
607.52	containing over 80% but not over 90% by weight of silicon	1.2	1
607.53	containing over 90% by weight of silicon	2.4	2
607.55	Ferrosilicon chromium	10%	10%
607.57	Ferrosilicon manganese per pound Mn content	0.56¢ + 4.5%	0.46¢ + 3.5%

Sources: The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa. Tariff Schedules of the United States, Annotated (1971) TC Publication 344.

Silver

J. G. GEORGE

Canada's mine production of silver in 1971, 44,938,000 troy ounces*, was 0.69 million ounces greater than in 1970 and only slightly less than the all-time high of 1968. The increase was mainly attributable to greater output of several base-metal mines which produce silver as a byproduct, particularly that of Anvil Mining Corporation Limited which operated at a much higher mill rate at its lead-zinc-silver property in the Yukon Territory. Declines in production in Newfoundland, Nova Scotia, Ontario and the Northwest Territories were more than offset by higher output in the other provinces and the Yukon Territory. Ontario was again the leading silver-producing province primarily because of the substantial byproduct silver produced at the Kidd Creek base-metal mine of Ecstall Mining Limited near Timmins. Output in the Cobalt-Gowganda area of Ontario was about one million ounces less than in 1970. The value of Canadian production was $70 million, almost $12 million less than in 1970 because of lower silver prices.

The principal source of silver was again base-metal ores, which accounted for some 95 per cent of total production. The major portion of the remaining 5 per cent came from silver-cobalt ores mined in 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 declining order of output were Ecstall Mining Limited in Ontario, Cominco Ltd. (Sullivan mine) in southeastern British Columbia, and United Keno Hill Mines Limited and Anvil Mining Corporation Limited, both in the Yukon Territory. Base-metal ores mined by these four producers accounted for some 50 per cent of total Canadian silver production. Largest producer in the Cobalt-Gowganda area of Ontario was again Silverfields Mining Corporation Limited with output of 1,129,330 ounces.

Canadian Copper Refiners Limited at Montreal East, Quebec, was again Canada's largest producer of refined silver. It recovered 12,885,000 ounces from the treatment of anode and blister copper. The silver refinery of Cominco Ltd. at Trail, British Columbia, was the second largest producer, recovering 5,559,823 ounces in the processing of silver-bearing lead and zinc ores and concentrates. 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 (formerly East Coast Smelting and Chemical Company Limited) recovered byproduct silver from lead-zinc concentrates treated in an Imperial Smelting Process blast furnace. Late in 1970 Kam-Kotia Mines Limited, Refinery Division, decided for economic reasons to close down its silver refinery at Cobalt, Ontario. The local mines concerned were notified that no shipments would be received after March 31, 1971, and the refinery was finally closed down in February 1972.

Canada's exports of silver in ores and concentrates and as refined metal totalled 43,384,345 ounces in 1971, or some 2.6 million ounces less than the corresponding amount in 1970. The United States

*Wherever used in this review, the term "ounce" refers to the troy ounce.

continued to be our major market, importing more than 76 per cent of Canada's total exports. Canadian imports of refined silver dropped sharply from 4,319,357 ounces in 1970 to 722,815 ounces in 1971. Virtually all of the imports came from the United States with a very minor quantity coming from Britain.

Statistics are not yet available for Canadian consumption of silver in 1971, but in 1970 reported consumption totalled 6,034,028 ounces.

Table 1. Canada, silver production, trade and consumption, 1970-71

	1970		1971[p]	
	(ounces)	($)	(ounces)	($)
Production[1]				
By provinces and territories				
Ontario	19,876,430	36,771,396	17,575,000	27,417,000
British Columbia	6,511,316	12,045,934	7,738,000	12,071,000
Yukon Territory	4,240,709	7,845,312	5,852,000	9,129,000
Quebec	4,261,959	7,884,624	5,642,000	8,802,000
New Brunswick	4,577,956	8,469,219	5,011,000	7,817,000
Northwest Territories	2,764,642	5,114,587	1,711,000	2,669,000
Manitoba	660,755	1,222,397	714,000	1,114,000
Newfoundland	793,402	1,467,794	420,000	655,000
Saskatchewan	491,953	910,113	220,000	343,000
Nova Scotia	71,668	132,586	55,000	86,000
Alberta	14	26	–	–
Total	44,250,804	81,863,988	44,938,000	70,103,000
By source				
Base-metal ores	41,134,942		42,819,000	..
Gold ores	306,347	..	271,000	..
Silver-cobalt ores	2,808,229	..	1,847,000	..
Placer gold ores	1,286	..	1,000	..
Total	44,250,804	81,863,988	44,938,000	70,103,000
Refined silver	30,391,652	..	20,284,543	..
Exports				
In ores and concentrates				
United States	13,217,030	20,627,966	16,266,628	23,052,000
Japan	3,487,850	5,877,732	4,656,573	6,583,000
West Germany	1,477,693	1,938,475	1,659,963	1,786,000
Belgium and Luxembourg	2,932,035	4,472,196	1,040,390	1,279,000
Britain	251,930	299,799	250,421	312,000
Sweden	248,345	534,307	175,563	266,000
France	125,822	117,006	15,603	14,000
Other countries	79,219	59,189	1,117,833	1,082,000
Total	21,819,924	33,926,670	25,182,974	34,374,000
Refined metal				
United States	23,096,055	43,415,544	16,795,421	25,865,000
Belgium and Luxembourg	985,241	1,716,758	1,162,649	1,959,000
West Germany	–	–	231,372	400,000
Trinidad-Tobago	9,070	18,408	4,355	7,000
Jamaica	2,817	5,814	2,569	4,000
Venezuela	2,572	5,372	1,751	3,000
Other countries	103,769	191,900	3,254	9,000
Total	24,199,524	45,353,796	18,201,371	28,247,000

Table 1 (cont'd)

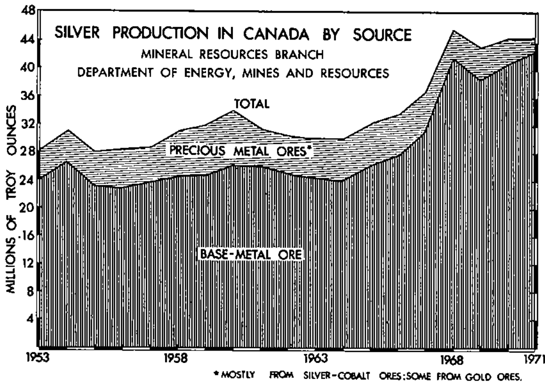
	1970		1971p	
	(ounces)	($)	(ounces)	($)
Imports				
Refined metal				
United States	4,314,913	8,042,376	705,901	1,165,000
Britain	4,444	9,502	16,914	30,000
Mexico	–	–	–	–
Bolivia	–	–	–	–
Total	4,319,357	8,051,878	722,815	1,195,000
Consumption, by use				
Coinage			..	
Silver salts	468,095		..	
Silver alloys	565,002		..	
Sterling	1,167,289		..	
Wire and rod	24,366		..	
Other[2]	3,809,276		..	
Total	6,034,028		..	

Source: Statistics Canada.
[1]Includes: recoverable silver in ores, concentrates and matte shipped for export; silver in crude gold bullion produced; silver in blister and anode copper produced at Canadian smelters; silver in base bullion produced from domestic ores; and silver bullion produced from the treatment of domestic silver-cobalt ores at Cobalt, Ontario.
[2]Includes sheet and miscellaneous uses.
pPreliminary; – Nil; .. Not available.

Table 2. Canada, silver price, production, trade and consumption, 1962-71

		Production		Exports			Imports,	Consumption,[3]
	Price[1]	All Forms[2]	Refined Silver	In Ores and Concentrates	Refined Silver	Total	Refined Silver	Refined Silver
	($ Can. per oz)				(ounces)			
1962	1.165	30,422,972	16,749,356	8,861,858	9,445,094	18,306,952	15,182,336	15,419,342
1963	1.385	29,932,003	19,772,408	8,286,756	10,834,629	19,121,385	7,950,972	17,574,628
1964	1.400	29,902,611	20,744,682	9,478,317	10,583,439	20,061,756	5,197,764	18,775,307
1965	1.399	32,272,464	20,630,190	12,245,877	11,268,110	23,513,987	13,413,434	30,170,097
1966	1.398	33,417,874	21,298,325	11,850,469	12,221,142	24,071,611	14,477,787	21,303,704
1967	1.720	36,315,189	20,658,556	10,407,418	13,735,675	24,143,093	5,383,872	14,576,608
1968	2.306	45,012,797	34,611,344r	21,502,022	28,104,562	49,606,584	14,060,635	13,598,358
1969	1.928	43,530,941	38,678,520r	21,883,028	34,658,937	56,541,965	19,168,785	5,747,068
1970	1.849	44,250,804	30,391,652	21,819,924	24,199,524	46,019,448	4,319,357	6,034,028
1971p	1.561	44,938,000	20,284,543	25,182,974	18,201,371	43,384,345	722,815	..

Source: Statistics Canada for all figures except prices. Prices are those quoted by Cominco Ltd.
[1]Annual average. [2]Includes recoverable silver in ores, concentrates and matte shipped for export; in crude gold bullion produced; in blister and anode copper produced at Canadian smelters; in base bullion produced from domestic ores; in bullion produced from the treatment of silver-cobalt ores at Cobalt, Ontario. [3]Includes consumption for coinage.
pPreliminary; rRevised; .. Not available.



World production and consumption

Silver production in the noncommunist world in 1971, according to an estimate of Handy and Harman,* was 239.7 million ounces, or 11.4 million ounces less than in 1970. In 1971 noncommunist world consumption for both industrial and coinage uses, excluding requirements for United States coinage which are supplied from Treasury stocks, was 374.0 million ounces. The gap between new production and consumption, not including United States coinage requirements, was some 134 million ounces or somewhat less than in 1970.

Consumption of silver for coinage in the noncommunist world, excluding the United States, was 16.5 million ounces or about 3.1 million ounces less than in 1970. Except for a minor quantity used in 1971 in the minting of commemorative coins, silver has not been used in the production of Canadian coinage since 1968, when the Royal Canadian Mint consumed 7.4 million ounces.

Based on preliminary figures, Canada in 1971 was again the world's largest mine producer of silver; other leading producers were Mexico, the United States and Peru.

New production of silver in the United States declined from 45.0 million ounces in 1970 to an estimated 41.0 million ounces in 1971. In the United States, the world's largest silver consumer, consumption for industrial uses and coinage was 126.0 and 2.5 million ounces, respectively, in 1971. The large deficit in requirements was again met by imports, demonitized coinage, secondary silver derived from discarded jewelry, silverware, etc., liquidation of speculative holdings and withdrawals from United States Treasury stocks. Requirements for United States coinage were again obtained from Treasury stocks which (in the form of bullion and coin bars) were increased during 1971 from 25.1 to 48.0 million ounces, excluding 139.5 million ounces held in the strategic stockpile. The stockpile objective also remained at 139.5 million ounces, having been reduced from 165.0 million ounces in March 1970. The United States Mint used 2.5 million ounces of silver for coinage in 1971 compared with 0.7 million ounces in 1970.

The Silver Market 1971, compiled by Handy and Harman.

Table 3. World production of silver, 1970-71

	1970^{p}	1971^{e}
	(ounces)	
Canada	44,615,000[1]	46,500,000[2]
Mexico	42,889,000	43,500,000
United States	45,006,000	41,000,000
U.S.S.R.^{e}	38,000,000	..
Peru	38,078,000	35,100,000
Australia	26,126,000	..
Japan	10,795,000	..
Bolivia	6,816,000	..
Sweden	6,109,000	..
East Germany^{e}	4,800,000	..
Honduras	3,816,000	..
Republic of South Africa	3,527,000	..
Yugoslavia	3,417,000	..
Other countries	27,751,000	..
Total	301,745,000	305,200,000

Sources: 1970 statistics from U.S. Bureau of Mines *Minerals Yearbook, 1970.* Statistics for 1971 from U.S. Bureau of Mines Commodity Data Summaries, January 1972.
[1]This figure has since been revised to 44,250,804 by Statistics Canada.
[2]A later preliminary estimate for this figure by Statistics Canada is 44,938,000.
^{p}Preliminary; ^{e}Estimate; .. Not available.

In May 1971 the United States Mint began the minting of 150 million Eisenhower dollar coins containing 40 per cent silver. Production of these commemorative coins was authorized in a provision included in Public Law PL-91-607 signed by President Nixon 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 will be required. Part of these requirements resulted from a transfer of 25.5 million ounces from the strategic stockpile to the United States Mint, also authorized in Public Law PL-91-607.

Late in February 1971 representatives of the leading silver producers of the western hemisphere met in Washington, D.C., and announced the formation of a new organization, The Silver Institute, Inc., whose main purpose is to disseminate information about silver and promote its uses for industrial and other purposes. The offices and headquarters of the Institute are in Washington and membership is open to miners and refiners of silver throughout the world without geographical limitation. Companies participating in the work of the Institute from its inception include producers of silver in the United States, Canada, Honduras and Peru. The principal objective of the new organization will be to disseminate information as widely as possible regarding new applications in the use of silver in the electronics, electrical, photographic, chemical and other industries. Initially a complete literature survey is being made to accumulate information regarding silver applications throughout the world in both communist and non-communist countries.

Prompted by the decline in silver prices, representatives of the governments of Australia, Canada, Peru, the United States and Mexico attended a meeting in Mexico City from June 16 to 18, 1971 at the invitation of the Mexican Government. The conversations included a review of statistics as well as a discussion of factors affecting all aspects of the silver market, including sources of supply, movements in demand, stocks and existing market mechanisms as well as all factors influencing these market mechanisms. It was observed from available data that there is at present, and will be in the foreseeable future, a deficit between combined primary and secondary production of silver and total demand. It was also foreseeable that this deficit will continue to be covered by available stocks of various kinds. Whereas the meeting was not for the purpose of formulating recommendations with regard to the current situation of the silver market, it recognized that it is to the advantage of producers and consumers alike to have adequate and stable prices, and some observations in this respect were examined.

In view of the decline in silver prices in the latter part of 1971 to a level of around $1.30 an ounce, it is useful to note the terms of Section 104 of the Coinage Act of 1965 enacted by the United States Government on July 23, 1965. This section authorizes and directs the Treasury Department to purchase, at a price of $1.25 a fine ounce, any silver domestically mined after July 23, 1965 and tendered to a United States mint or assay office within a year after the month in which the ore, from which it is derived, was mined.

On November 10, 1971, Bill H.R. 11692 was introduced in the United States House of Representatives proposing an amendment to Section 104 of the Coinage Act of 1965 to permit the Secretary of the Treasury to purchase such newly mined silver, as outlined in the Act, at such price greater than $1.25 an ounce as he may determine from time to time to be appropriate. The Bill was subsequently referred to the Committee on Banking and Currency for further study.

Canadian exports to the United States of refined silver and silver contained in ores and concentrates were not subject to the 10 per cent ad valorem surcharge on foreign imports announced by President Nixon on August 15, 1971, and later rescinded by a proclamation signed by the President on December 20, 1971.

The New York silver price fluctuated throughout 1971 between a high of $1.752 an ounce on April 8 and a low of $1.288 on November 3. At year-end it was $1.380.

Outlook

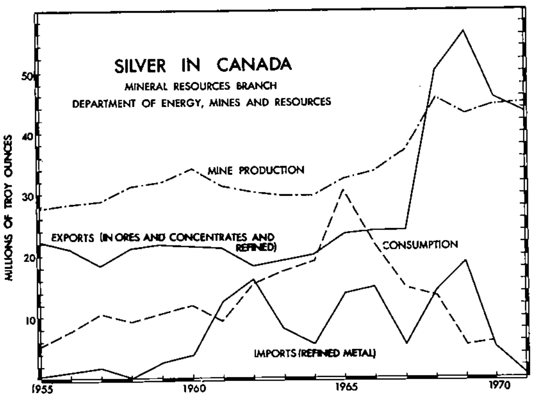
Canada's mine production of silver in 1972 is forecast to be some 46 million ounces and from 1973-77 it could range between 45 and 50 million ounces annually.

Despite the reported decline in consumption of silver in recent years, it is expected that consumption will continue to exceed primary production since mine output of silver is largely related to the production of the major base-metal ores. About 65 per cent (some 95 per cent in Canada) of silver output 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. However, in the near term there should be no real shortage for industrial requirements since sufficient quantities of secondary silver, speculative holdings and some hoarded silver coins will continue to find their way into the market. Additional supplies may also continue to come from Russia and India.

The silver industry has weakened during the past year mainly because of the economic recession in the United States and other western industrial nations. No substantial improvement in consumption or price is anticipated until there is a significant upswing in the free world economic performance.

Canadian developments

Yukon Territory. A significant increase in silver production in 1971 in the Yukon Territory resulted mainly from greater byproduct output at the lead-zinc-silver property of Anvil Mining Corporation Limited at Faro. Also contributing to the Territory's



increase was somewhat higher output at the lead-zinc-silver-gold property of United Keno Hill Mines Limited near Mayo. Hudson Bay Mining and Smelting Co., Limited continued development work at its silver-lead-zinc 'Tom' claims on the Canol Road near the Yukon Territory-Northwest Territories border. Diamond drilling and underground development work have indicated that the east and west zones now contain an estimated 8,600,000 short tons* grading 8.1 per cent lead, 8.4 per cent zinc and 2.75 ounces silver a ton. Matt Berry Mines Limited continued exploration work on its silver-base-metals property in the Frances Lake area of the Yukon Territory. It is a joint venture project with Canadian Nickel Company Limited (a subsidiary of The International Nickel Company of Canada, Limited) and Metallgesellschaft Canada Limited. Previous diamond drilling indicated a deposit containing 415,000 tons with grade averaging 9.12 per cent lead, 6.25 per cent zinc, and 4.33 ounces of silver a ton.

Northwest Territories. The two principal silver producers in the Northwest Territories were again Echo Bay Mines Ltd. and Terra Mining and Exploration Limited, which operate silver-copper properties near Port Radium on the east shore of Great Bear Lake. Under an agreement with Bathurst Norsemines Ltd., Cominco Ltd. did further diamond drilling and exploration work on the Norsemines silver-base-metals prospect in the Hackett River area of the Mackenzie mining district. One of the important discoveries on the property is the Main zone deposit which has been traced for 3,300 feet along strike with indicated grade of some 7 ounces of silver and 0.05 ounce of gold a ton, 8.5 per cent zinc, 1.4 per cent lead and 0.25 per cent copper. Drilling indicated the lens to be about 60-70 feet thick with favourable structure extending to below 1,000 feet.

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 and Bluebell mines in southeastern British Columbia, and from purchased ores and concentrates. In December 1971 operations were suspended at the Bluebell property because of exhaustion of ore reserves. The mine had been in operation intermittently between 1895 and 1952, and had been in continuous operation since 1952. It was British Columbia's oldest known lead-zinc mine.

Mill tune-up operations began in July 1971 at the 100-ton-a-day concentrator of Columbia Metals Corporation Limited, at its silver-lead-zinc property near Ferguson in southeastern British Columbia. Average grade of ore indicated by underground work and diamond drilling on the company's True Fissure zone is 6 per cent lead, 6.7 per cent zinc and 6.9 ounces of silver a ton. Negotiations for financing construction of a 100-ton-a-day pilot mill were under way at the Crest Silver property controlled by Ardo Mines Ltd., 12 miles northeast of Stewart, B.C. The ore in the No. 1 adit area is mainly high-grade silver and contains lead, zinc, copper and some gold.

Manitoba-Saskatchewan. In Manitoba and Saskatchewan most of the silver continued to come from eight base-metal mines operated by Hudson Bay Mining and Smelting Co., Limited near Flin Flon and Snow Lake, Manitoba. Two of these mines, Anderson Lake and Dickstone, were brought into production by the company in November 1970. Two other new mines were being developed by Hudson Bay in the Flin Flon-Snow Lake area, namely Ghost Lake and White Lake, and were scheduled to begin production during the second half of 1972. The company's Flexar mine is expected to suspend operations in the latter part of 1972 because of exhaustion of ore reserves.

Ontario. Ontario was again, by far, the leading silver-producing province with its output accounting for almost 40 per cent of Canadian mine production. Ecstall Mining Limited continued to be the largest producer, recovering almost 13 million ounces in copper, lead and zinc concentrates at its Kidd Creek property. This mine was also the largest single mine producer of silver in Canada. In the Cobalt-Gowganda area of northern Ontario, over 2.75* million ounces were derived from silver-cobalt mines. A significant portion of the remainder was byproduct production of Noranda Mines Limited (Geco Division) in the Manitouwadge area.

Early in March 1972 mill tune-up operations began at the zinc-copper-silver property of Selco Mining Corporation Limited, South Bay Division, in the Uchi Lake area of northwestern Ontario. Mill capacity is 500 tons of ore a day. At the beginning of operations sufficient ore had been indicated to support operations for five years at the initial rate of milling. The silver content of the copper and zinc concentrates produced in 1971 is not available.

Mattabi Mines Limited, owned 60 per cent by Mattagami Lake Mines Limited and 40 per cent by Abitibi Paper Company Ltd., was expected to begin operations in the third quarter of 1972 at its zinc-copper-lead-silver property in the Sturgeon Lake area, 50 miles north of the town of Ignace, Ontario. The company's open-pit mine is being developed for production at an anticipated rate of 3,000 tons of ore a day. Ore reserves at the end of 1971 were reported to be almost 13 million tons grading 7.6 per cent zinc, 0.91 per cent copper, 0.84 per cent lead, and 3.13 ounces of silver and 0.007 ounce of gold a ton.

(text continued on page 15.)

*Wherever used in this review, the term 'ton' refers to the short ton of 2,000 pounds avoirdupois, unless otherwise stated.

*Based on actual mine production during the calendar year 1971.

Table 4. Principal silver (mine) producers in Canada, 1971

Company and Location	Mill Capacity	Type of Ore Milled	Silver Grade 1971 [1970]	Ore Produced 1971 [1970]	Contained Silver Produced 1971 [1970]	Remarks
	(tons of ore/day)		(oz/ton)	(tons)	(ounces)	
Yukon Territory						
Anvil Mining Corporation Limited, Faro	7,700	Zn, Pb, Ag	. . [. .]	2,673,000 [1,961,000]	2,934,894 [1,497,901]	Mill capacity increased from 6,600 to 7,700 tons a day
United Keno Hill Mines Limited, Hector-Calumet, Elsa, Husky and No Cash mines, Mayo District	550	Ag, Zn, Pb	30.57 [27.30]	94,754 [93,215]	3,007,463 [2,663,584]	Hydraulic fill plant to be installed for cut-and-fill method of stoping at Husky mine
Venus Mines Ltd., Carcross	300	Ag, Pb, Zn	. . [5.30]	. . [23,796]	. . [80,738]	Operations suspended in June 1971
Northwest Territories						
Echo Bay Mines Ltd., Port Radium	100	Ag, Cu	68.9 [70.0]	36,820 [36,924]	2,536,172 [2,511,267]	Plans to continue exploration in Great Bear Lake area
Terra Mining and Exploration Limited, Camsell River area	300	Ag, Cu	33.7 [13.7]	48,715 [32,867]	1,193,086 [393,054]	Plans to explore and diamond drill No. 7, 8 and 9 veins to establish further ore reserves
British Columbia						
Bethlehem Copper Corporation Ltd., Highland Valley	15,000	Cu, Ag, Au	. . [. .]	5,625,999 [5,450,746]	. . [161,542]	Mill capacity was to be increased to 16,000 tons a day by early 1972
Brenda Mines Ltd., Peachland	24,000	Cu, Mo, Ag, Au	. . [. .]	8,987,210 [7,326,559]	300,211 [225,411]	Plans to install copper regrind circuit to upgrade concentrates
Cominco Ltd., Sullivan mine, Kimberley	10,000	Zn, Pb, Ag	. . [. .]	2,005,301 [2,194,743]	3,666,522 [2,933,096]	Cominco's total output of refined silver from all sources was 5,559,823 ounces in 1971
Bluebell mine, Riondel	750	Zn, Pb, Ag	. . [. .]	256,797 [245,529]	. . [. .]	Operations suspended in December 1971 because of depletion of ore reserves
Copperline Mines Ltd., Ruth-Vermont mine, Golden	600	Ag, Pb, Zn	. . [. .]	58,593 [36,228]	. . [139,150]	Mill tune-up operations began in September 1970; suspended in June 1971

Table 4 (cont'd)

Company and Location	Mill Capacity	Type of Ore Milled	Silver Grade 1971 [1970]	Ore Produced 1971 [1970]	Contained Silver Produced 1971 [1970]	Remarks
	(tons of ore/day)		(oz/ton)	(tons)	(ounces)	
The Granby Mining Company Limited, Granisle mine, Babine Lake	6,500	Cu, Au, Ag	. . [. .]	2,288,952 [2,393,161]	102,020 [105,274]	Construction began on expansion of concentrator to 14,000 tons a day; scheduled for completion in September 1972
The Granby Mining Company Limited, Phoenix Copper Division, Greenwood	2,400	Cu, Au, Ag	0.236 [0.243]	902,325 [862,156]	134,298 [135,863]	At September 30, 1971 ore reserves were calculated at 1.1 million tons averaging 0.78 per cent copper that can be mined at an ore-to-waste ratio of 1:2.7
Granduc Operating Company, Stewart	7,000	Cu, Ag, Au	. . [0.43]	1,498,854 [105,230]	414,473 [32,682]	Operations began September 1, 1970
Kam-Kotia Mines Limited, Silmonac mine, Slocan District	150	Ag, Pb, Zn	17.99 [19.0]	39,154 [13,232]	681,407 [245,827]	Mill tune-up operations began September 1970
Reeves MacDonald Mines Limited	1,000 (treated at central mill)					
Reeves mine		Zn, Pb, Ag	. . [. .]	25,296 [107,312]	7,207 [7,905]	Operations curtailed in July 1971 due to depletion of known ore reserves
Annex mine		Zn, Pb, Ag	2.51 [3.3]	166,089 [70,714]	358,428 [198,283]	Exploration work continuing
Teck Corporation Limited, Beaverdell mine, Beaverdell (formerly Leitch Mines Limited)	115	Ag, Pb, Zn	17.52 [13.37]	36,404 [33,225]	637,797 [444,290]	At current silver prices there appears to be sufficient ore developed for at least two years of operation
Utah Mines Ltd., Island Copper mine, Coal Harbour, Vancouver Island	33,000	Cu, Ag, Au	. . [-]	1,040,608 [-]	216,000 [-]	Mill tune-up operations began October 1971
Dankoe Mines Ltd. (formerly Utica Mines Ltd.), Keremeos	350	Ag, Au, Pb, Zn	– [. .]	– [18,603]	– [130,274]	Mill ceased operations March 31, 1970
Wesfrob Mines Limited, Tasu Harbour, Queen Charlotte Islands	10,000	Fe, Cu, Ag	. . [. .]	996,471[1] [1,200,000][1]	226,366 [237,000]	Silver contained in copper concentrate produced as byproduct of iron ore mining and beneficiation

Western Mines Limited, Buttle Lake, Vancouver Island	1,000	Zn, Cu, Pb, Ag	1.6 [1.36]	386,541 [386,976]	479,923 [386,976]	Decline at Myra Falls property advanced 935 feet to completion
Manitoba-Saskatchewan						
Hudson Bay Mining and Smelting Co., Limited	6,000 (treated at central mill at Flin Flon)	Cu, Zn, Pb, Ag	0.5 [0.61]	1,084,000 [1,709,130]	417,276 [1,034,209]	Production curtailed as entire Flin Flon and Snow Lake operations were closed down from January 27 to June 21, 1971 because of labour strike
Flin Flon, Man.						
Flexar mine		Cu, Zn, Ag	0.2 [0.2]	66,300 [120,700]		
Flin Flon mine		Cu, Zn, Ag	0.8 [0.8]	272,300 [622,300]		
Schist Lake mine		Cu, Zn, Ag	0.7 [1.0]	50,100 [100,700]		
Snow Lake, Man.						
Anderson Lake mine		Cu, Ag, Au	0.3 [0.3]	224.400 [59,600]		
Chisel Lake mine		Zn, Cu, Pb, Ag	0.9 [0.9]	163,200 [281,500]		
Dickstone mine		Cu, Zn, Ag	0.4 [0.4]	140,800 [26,100]		
Osborne Lake mine		Zn, Cu, Ag	. . [. .]	153,900 [319,400]		
Stall Lake mine		Cu, Zn, Au, Ag	0.5 [0.6]	11,700 [179,200]		
Ontario						
Big Nama Creek Mines Limited, Manitouwadge	ore custom-milled	Zn, Cu, Ag	1.07 [0.99]	41,717 [88,965]	. . [29,643]	Mining operations suspended in September 1971 because of depletion of known ore reserves
Ecstall Mining Limited (Texas Gulf Sulphur Company), Kidd Creek mine, Timmins	10,000	Zn, Cu, Ag, Pb	4.05 [. .]	3,673,350 [3,584,124]	12,768,177 [12,233,834]	Shaft from surface to 3,050 feet completed in August 1971
Noranda Mines Limited, Geco Division, Manitouwadge	5,000	Cu, Zn, Ag, Pb	2.03 [1.82]	1,759,952 [1,366,176]	2,593,566 [1,978,752]	Company plans to install system to recycle tailings water back to mill for process purposes
Selco Mining Corporation Limited, South Bay Division, Uchi Lake area (formerly South Bay Mines Limited)	500	Zn, Cu, Ag	. . [-]	130,019 [-]	. . [-]	Mill tune-up operations began in March 1971

Table 4 (cont'd)

Company and Location	Mill Capacity	Type of Ore Milled	Silver Grade 1971 [1970]	Ore Produced 1971 [1970]	Contained Silver Produced 1971 [1970]	Remarks
	(tons of ore/day)		(oz/ton)	(tons)	(ounces)	
The International Nickel Company of Canada, Limited, Sudbury, Ont. and Thompson, Man.	102,500	Ni, Cu	. . [. .]	21,847,000 [28,300,000]	1,743,000[2] [1,051,000][2]	Due to general economic slowdown, company announced, in August 1971, that production cutbacks would be made and that by April 1972 production would be at a rate of some 30 per cent less than that planned for 1971
Willroy Mines Limited, Willroy and Willecho mines, Manitouwadge	1,600	Zn, Cu, Ag, Pb	1.36 [1.99]	427,589 [388,005]	411,052 [520,973]	1971 production figures include output from Big Nama Creek Mines Limited and ore grades are averages including Big Nama production
Agnico Mines Limited, 407 mine, 96 shaft mine and Penn-Canadian mine, Cobalt district	400	Ag, Cu, Co, Ni	18.38 [17.28]	29,960 [64,695]	529,485 [1,070,031]	Plans to sink Trout Lake mine shaft 250 feet below present 850-ft level and establish 3 new levels
Hiho Silver Mines Limited, Cleopatra and Giroux Lake properties in Cobalt district	150	Ag, Cu, Co, Ni	– [7.11]	– [46,801]	– [332,847]	Operations suspended late in 1970
Manridge Mines Limited, Gowganda district	ore custom-milled	Ag, Cu, Co, Ni	– [21.54]	– [8,096]	– [130,067]	Operations suspended at end of 1970
Patricia Silver Mines Limited, Nipissing-North property, Cobalt district	ore custom-milled	Ag, Cu, Co, Ni	. . [. .]	9,068 [. .]	142,206 [187,947]	Mining operations suspended
Siscoe Metals of Ontario Limited, Gowganda district	275	Ag, Cu, Co, Ni	23.9 [13.0]	42,002 [38,614]	979,282 [407,785]	Discovery of new ore on 350-, 525- and 650-ft levels in Main mine supplied bulk of 1971 production

Silverfields Mining Corporation Limited, Cobalt district (subsidiary of Teck Corporation Limited)	250	Ag, Cu, Co, Ni	14.8 [14.5]	76,149 [78,583]	1,129,330 [1,119,331]	Regrind circuit added to mill to improve quality of concentrates produced and to increase proportion of bullion production
Quebec						
Campbell Chibougamau Mines Ltd., Chibougamau district	4,000	Cu, Au, Ag	0.2717 [0.2842]	1,294,285 [1,309,718]	227,645 [243,054]	Plans to engage in more underground exploration work
Delbridge Mines Limited, Noranda	ore custom-milled	Zn, Cu, Ag, Au	2.86 [3.48]	154,172 [196,844]	245,382 [421,563]	Operations suspended in September 1971
D'Estrie Mining Company Ltd., Stratford Centre	ore custom-milled	Cu, Zn, Pb, Ag	0.974 [. .]	83,506 [. .]	55,769 [. .]	Plans to continue stope preparations
Falconbridge Copper Limited, Lake Dufault Division, Noranda (formerly Lake Dufault Mines Limited)	1,500	Cu, Zn, Ag	0.60 [0.53]	509,095 [419,171]	227,143 [169,743]	Commercial production from new Millenbach copper-zinc-silver mine began November 1, 1971
Falconbridge Copper Limited, Opemiska Division, Chapais, (formerly Opemiska Copper Mines (Quebec) Limited)	3,000	Cu, Au, Ag	0.31 [0.33]	1,074,047 [835,942]	285,254 [231,173]	Exploration on 2,875-ft elevation (18th level) intersected new ore structure between Perry and Robitaille shafts. Diamond drilling indicates significant zone of slightly below average mine grade
Gaspé Copper Mines, Limited, Gaspé mine, Murdochville	11,000	Cu, Mo, Ag, Au	. . [. .]	3,980,525 [4,070,853]	554,640 [612,418]	Mill capacity to be expanded to 34,000 tons a day by 1973
Madeleine Mines Ltd., Ste-Anne-des-Monts	2,500	Cu, Ag	. . [0.30]	869,467 [848,570]	197,116 [197,768]	In 1971 began preparatory work for sinking 1,000-ft winze from 2,900 to 1,900 level
Manitou-Barvue Mines Limited, Golden Manitou mine, Val-d'Or	1,600	Zn, Pb, Cu, Ag	4.42 [4.66]	225,915[3] [273,200][3]	769,838 [1,014,660]	Due primarily to lower silver prices, mining and milling of silver-zinc orebody temporarily suspended October 29, 1971
Mattagami Lake Mines Limited, Matagami	3,850	Zn, Cu, Ag, Au	1.07 [0.86]	1,386,160 [1,430,864]	597,741 [496,211]	Excavation of 960 level crusher room completed; second underground crusher and conveyor installation 95 per cent completed by end of 1971
Noranda Mines Limited, Horne mine, Noranda	3,000	Cu, Au, Ag	0.435 [0.408]	682,618 [654,262]	187,284 [151,247]	Horne mine ore expected to be exhausted by end of 1973

Table 4 (cont'd)

Company and Location	Mill Capacity	Type of Ore Milled	Silver Grade 1971 [1970]	Ore Produced 1971 [1970]	Contained Silver Produced 1971 [1970]	Remarks
	(tons of ore/day)		(oz/ton)	(tons)	(ounces)	
Normetal Mines Limited, Normetal	1,000	Zn, Cu, Ag, Au	1.50 [1.474]	335,298 [348,100]	321,480 [321,583]	Mine on a salvage basis; expected to close in summer of 1973
Orchan Mines Limited, Matagami	1,900	Zn, Cu, Ag, Au	1.27 [1.36]	409,492 [414,521]	254,222 [225,877]	Underground development and exploration drilling added 205,780 tons in new No. 5 orebody between 5th and 7-50 levels. Proven reserves in Orchan mine at January 1, 1972 totalled 2,263,300 tons averaging 9.3 per cent zinc and 1.1 per cent copper
Quemont Mines Limited, Noranda	2,400	Cu, Zn, Au, Ag	1.03 [0.91]	332,916 [299,636]	125,889 [127,850]	Mining and milling operations ceased November 11, 1971 when ore exhausted
Sullivan Mining Group Ltd., Cupra Division[4], Stratford Centre	1,400	Cu, Zn, Pb, Ag	1.050 [0.990]	134,663 [193,450]	97,842 [. .]	Ore reserves at August 31, 1971: 521,000 tons averaging 2.49 per cent copper, 0.60 per cent lead, 3.58 per cent zinc and 1 oz silver a ton
Sullivan Mining Group Ltd., Solbec Division[4], Stratford Centre	ore custom-milled	Cu, Zn, Pb, Ag	– [2.041]	– [132,060]	– [. .]	Mine closed in December 1970 because of exhaustion of ore reserves
The Patino Mining Corporation, Copper Rand Mines Division (Copper Cliff, Copper Rand, Jaculet and Portage mines), Chibougamau	2,800	Cu, Au, Ag	0.209 [0.205]	992,401 [837,187]	166,370 [135,765]	Deepening of Jaculet shaft completed; three new levels established

New Brunswick						
Brunswick Mining and Smelting Corporation Limited, No. 12 mine[5], Bathurst	6,000	Zn, Pb, Cu, Ag	2.44 [2.19]	1,567,000 [1,519,981]	. . [1,695,000]	Accelerated stope development program to increase production from mechanized cut-and-fill stopes under way; should be completed in 1972
N. 6 mine[6], Bathurst	3,500	Zn, Pb, Cu, Ag	1.86 [1.84]	847,000 [1,100,703]	. . [827,500]	No. 6 mill shut down from late June to mid-October 1971 to convert it to make separate lead and zinc concentrates instead of bulk zinc-lead concentrates
Heath Steele Mines Limited, Newcastle	3,000	Zn, Pb, Cu, Ag	2.21 [2.20]	972,456 [1,030,899]	1,068,212 [1,254,659]	Plans to sink No. 5 shaft in B zone orebody
Nigadoo River Mines Limited,[4] Bathurst	1,000	Zn, Pb, Cu, Ag	3.37 [3.59]	322,956 [319,689]	938,140 [903,897]	Mining and milling operations suspended January 4, 1972 following labour strike which began late in November 1971. Resumption of operations dependent upon improved metal prices and better economic conditions
Nova Scotia						
Dresser Industries, Division of Dresser Industries, Inc., Walton	140	Pb, Cu, Zn, Ag	4.35 [3.58]	16,125 [27,263]	53,730 [84,508]	Developed small cut-and-fill stopes where possible
Newfoundland						
American Smelting and Refining Company (Buchans Unit), Buchans	1,250	Zn, Pb, Cu, Ag	3.71 [3.73]	173,000 [359,000]	537,638 [1,146,489]	Production curtailed by labour strike which began June 21, 1971 and ended November 12, 1971

Source: Company reports.
[1]Ore produced in No. 3 zone only. [2]Silver delivered to markets. [3]Production does not include copper ore milled in separate circuit. [4]Production for fiscal years ending August 31. [5]Grade and production for 1971 represent ore produced at No. 12 mine only. [6]Grade and production for 1971 represent ore produced at No. 6 mine only.
– Nil; . . Not available.

Table 5. Prospective[1] silver producing mines in Canada

Company and Location	Year Production Expected	Mill or Mine Capacity	Indicated Ore Reserves	Average Grade of Ore				Remarks
				Lead	Zinc	Copper	Silver	
		(tons ore/day)		(%)	(%)	(%)	(oz/ton)	
British Columbia								
Nadina Exploration Limited, Owen Lake area	1972	500	450,000	1.60	7.1	0.81	9.72	Bralorne Can-Fer Resources Limited and Pacific Petroleums, Ltd. invested funds on a 50-50 basis to bring Nadina property into production. Bralorne will manage the project
Manitoba								
Hudson Bay Mining and Smelting Co., Limited,								
Ghost Lake Mine, Snow Lake	1972	..	261,000	0.91	11.6	1.42	1.14	Mine being developed by trackless methods
White Lake Mine, Flin Flon	1972	..	352,000	0.5	6.2	2.22	1.12	Production shaft completed at 1,373 feet below the collar
Ontario								
Mattabi Mines Limited, Sturgeon Lake area	1972	3,000	12,900,000	0.84	7.6	0.91	3.13	Initial open-pit production expected to begin during third quarter of 1972

[1] Those mines which have announced production plans. . . Not available.

Table 6. United States consumption of silver by end-use, 1970-71

	1970	1971p
	(ounces)	
Electroplated ware	11,436,929	10,909,206
Sterling ware	19,115,371	22,729,197
Jewelry	5,119,236	3,447,254
Photographic materials	38,043,926	36,072,350
Dental and medical supplies	1,804,104	1,484,435
Mirrors	1,385,902	1,111,409
Brazing alloys and solders	14,035,190	12,085,020
Electrical and electronic products		
batteries	6,342,306	5,631,050
contacts and conductors	25,183,261	27,953,893
Bearings	382,787	355,331
Catalysts	1,999,183	1,730,161
Miscellaneous[1]	3,555,576	5,636,360
Total net industrial consumption	128,403,771	129,145,666
Coinage	709,192	2,473,900
Total consumption	129,112,963	131,619,566

Source: United States Department of the Interior, Bureau of Mines Mineral Industry Surveys, Gold and Silver in December 1971 for 1970 figures, and in March 1972 for 1971.
[1]Includes silver-bearing copper, silver-bearing lead anodes, ceramic paints, etc.
pPreliminary.

Sturgeon Lake Mines Limited was formed late in 1971 to bring into production the silver - base-metal orebody discovered in September 1970 on property optioned from NBU Mines Limited (formerly New Brunswick Uranium Metals & Mining Limited) in the Sturgeon Lake area of northwestern Ontario. Falconbridge Copper Limited owns a 67 per cent interest in Sturgeon Lake Mines Limited and the remaining 33 per cent is held by NBU Mines Limited. The deposit was drilled systematically in 1971 to outline 1,928,000 tons grading 3.00 per cent copper, 7.85 per cent zinc and 4.54 ounces of silver a ton after allowing for 5 per cent dilution. The orebody extends to the north across the boundary on to Claim Group No. 23 owned by Mattagami Lake Mines Limited. Tonnage and grades of ore on Mattagami's side of the boundary amount to 826,250 tons grading 1.22 per cent copper, 9.19 per cent zinc, 1.40 per cent lead and 5.24 ounces of silver and 0.015 ounce of gold a ton. It is anticipated that much of the ore on both sides of the boundary can be mined by open pit methods and discussions have begun between the two companies to reach agreement on some form of joint operation.

Quebec. Silver output in the province, derived almost entirely from gold and base-metal ores, was somewhat higher in 1971 than in 1970. Manitou-Barvue Mines Limited, near Val-d'Or, Quebec, was the leading mine producer with byproduct output of over 700,000 ounces. Falconbridge Copper Limited, Lake Dufault Division (formerly Lake Dufault Mines Limited), brought its new Millenbach mine into production on November 1, 1971. The new mine's ore reserves were estimated at year-end to be 2,200,000 tons grading 3.1 per cent copper, 3.8 per cent zinc and 1.1 ounces of silver and 0.02 ounce of gold a ton.

New Brunswick. Silver output in New Brunswick was somewhat higher in 1971 than in 1970 mainly as a result of greater production at the silver - base-metal property of Brunswick Mining and Smelting Corporation Limited near Bathurst.

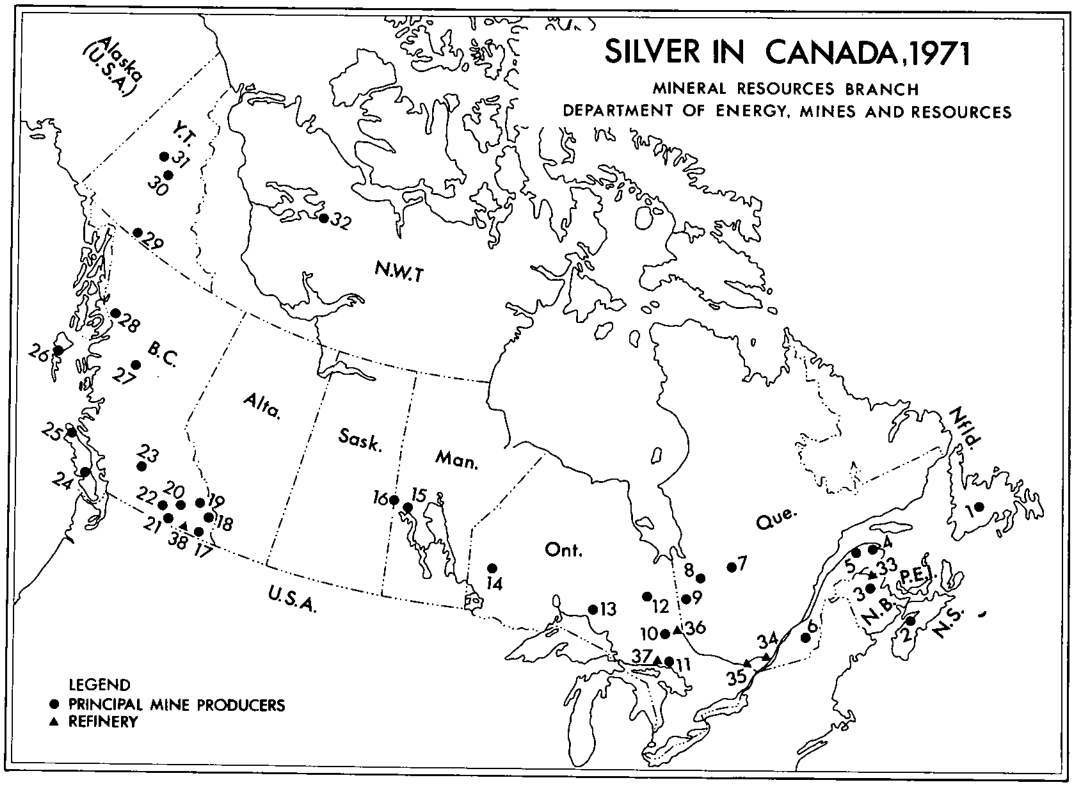
Because of metallurgical difficulties, The Anaconda Company (Canada) Ltd. suspended operations in November 1971 at the copper ore zone of its Caribou property in the Bathurst district of New Brunswick. The company also discontinued exploration and development work at its main Caribou zinc-lead-copper-silver deposit. The property is owned 75 per cent by Anaconda and 25 per cent by Cominco Ltd., with Anaconda in charge of operations.

Surface diamond drilling and exploration work continued at the lead-zinc-silver deposit jointly held by North American Rare Metals Limited and Mistango River Mines Limited. The property is in the Millstream River area about 20 miles west of Bathurst.

Uses

Although the number of industrial applications for silver has increased, significant quantities of the metal are still used in the manufacture of coinage. This is because it strongly resists corrosion, has good alloying properties, and has an attractive appearance and intrinsic value. The quantity of silver required for coinage, however, declined again because of the continuing trend towards using silverless coins or ones of reduced silver content. According to Handy and Harman, noncommunist world consumption of silver for coinage dropped from a high of 381.1 million troy ounces in 1965 to 19.0 million ounces in 1971. Silver is used extensively in jewelry, sterling and plated silverware, and as a decorative material, for 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. The photographic industry, in which the use of silver is based on the light-sensitivity and ease of reduction of certain silver compounds, has now become the metal's greatest single user.

Greater quantities are being used in the electrical and electronics industries because of the increasing 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 space flights. 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 are finding increased application in portable equipment where good output, long life and rechargeability are required. These batteries are also used in jet aircraft, missiles, satellites and space capsules where weight and dependability are of prime importance. High-energy silver-zinc batteries played a vital part in the historic Apollo voyages to the moon, servicing both the command and lunar excursion modules.

Prices

In 1971, the New York silver price remained relatively steady from January through May. It began a declining trend in June and in October it reached significantly lower levels which obtained for the rest of the year. A high of $1.752 an ounce prevailed on April 8 and a low of $1.288 on November 3; at year-end the price was $1.380. The London price ranged between a high of 72.60 pence* an ounce, equivalent to $1.755 (U.S.), on April 8 and a low of 51.00 pence, equivalent to $1.271 (U.S.), on November 2; at year-end it was 53.70 pence, equivalent to $1.357 (U.S.)

In 1971 the Canadian silver price closely followed its United States counterpart with the essential difference being the exchange rate; it fluctuated between a high of $1.770 an ounce on April 8 and a low of $1.298 on November 3. Average for the year was $1.561.

*Expressed in new British pence, following British conversion to decimal currency, as of February 11, 1971, at rate of 100 pence per pound sterling. Previous rate was 240 pence per pound.

Principal mine producers
(numbers refer to numbers on the map)

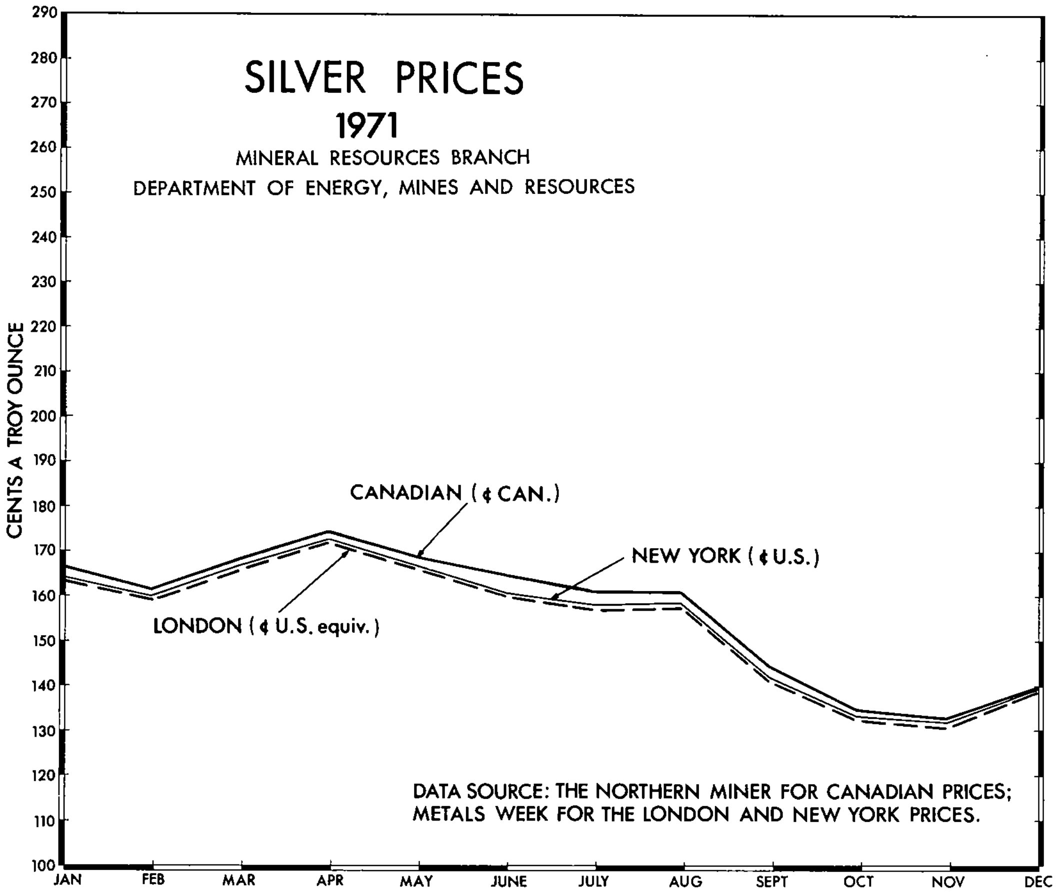
1. American Smelting and Refining Company (Buchans Unit)
2. Dresser Minerals, Division of Dresser Industries, Inc.
3. Brunswick Mining and Smelting Corporation Limited (No. 12 and 6 mines)
   Heath Steele Mines Limited
   Nigadoo River Mines Limited
4. Gaspé Copper Mines, Limited
5. Madeleine Mines Ltd.
6. D'Estrie Mining Company Ltd.
   Sullivan Mining Group Ltd., Cupra Division
7. Campbell Chibougamau Mines Ltd.
   Falconbridge Copper Limited, Opemiska Division
   The Patino Mining Corporation, Copper Rand Mines Division
8. Mattagami Lake Mines Limited
   Orchan Mines Limited
9. Delbridge Mines Limited
   Falconbridge Copper Limited, Lake Dufault Division
   Manitou-Barvue Mines Limited
   Noranda Mines Limited (Horne mine)
   Normetal Mines Limited
   Quemont Mines Limited
10. Agnico Mines Limited
    Patricia Silver Mines Limited
    Siscoe Metals of Ontario Limited
    Teck Corporation Limited, Silverfields Division
11. The International Nickel Company of Canada, Limited (Sudbury, Ont.)
12. Ecstall Mining Limited
13. Big Nama Creek Mines Limited
    Noranda Mines Limited, Geco Division
    Willroy Mines Limited
14. Selco Mining Corporation Limited, South Bay Division
15. Hudson Bay Mining and Smelting Co., Limited (Anderson Lake, Chisel Lake, Dickstone, Osborne Lake and Stall Lake mines)
16. Hudson Bay Mining and Smelting Co., Limited (Flexar, Flin Flon and Schist Lake mines)
17. Reeves MacDonald Mines Limited
18. Cominco Ltd. (Sullivan and Bluebell mines)
19. Copperline Mines Ltd. (Ruth-Vermont mine)
    Kam-Kotia Mines Limited (Silmonac mine)
20. Brenda Mines Ltd.
21. The Granby Mining Company Limited, Phoenix Copper Division
22. Teck Corporation Limited (Beaverdell mine)
23. Bethlehem Copper Corporation Ltd.
24. Western Mines Limited
25. Utah Mines Ltd.
26. Wesfrob Mines Limited
27. The Granby Mining Company Limited, Granisle mine
28. Granduc Operating Company
29. Venus Mines Ltd.
30. Anvil Mining Corporation Limited
31. United Keno Hill Mines Limited
32. Echo Bay Mines Ltd.
    Terra Mining and Exploration Limited

Refineries

33. Brunswick Mining and Smelting Corporation Limited, Smelting Division (formerly East Coast Smelting and Chemical Company Limited)
34. Canadian Copper Refiners Limited
35. Royal Canadian Mint
36. Kam-Kotia Mines Limited, Refinery Division
37. The International Nickel Company of Canada, Limited
38. Cominco Ltd.

Tariffs
Canada

Item No.		British Preferential	Most Favoured Nation	General
		(%)	(%)	(%)
32900–1	Ores of metals, nop	free	free	free
35800–1	Anodes of silver	free	free	free
35900–1	Silver in ingots, blocks, bars, drops, sheets or plates, unmanufactured; silver sweepings	free	free	free
35905–1	Scrap silver and metal alloy scrap containing silver (expires Oct. 31, 1972)	free	free	free
36100–1	Silver leaf	12½	20	30
36200–1	Articles consisting wholly or in part of sterling or other silverware, nop; manufactures of silver, nop	17½	22½	45



Tariffs (cont'd)

United States

Item No.		
601.39	Precious metal ores, silver content	free
605.20	Silver bullion, silver dore and silver precipitates	free
605.65	Rolled silver, effective Jan. 1, 1972	10.5%
605.70	Precious metal sweepings and other precious metal waste and scrap, silver content	free

Item No.		
	Silver (including platinum-plated or gold-plated silver, but not rolled silver), unwrought or semimanufactured, effective Jan. 1, 1972	(%)
605.46	platinum-plated	16
605.47	gold-plated	25
605.48	other unwrought silver	10.5

Sources: The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa. Tariff Schedules of the United States, Annotated (1972) TC Publication 452.
nop Not otherwise provided for.

Sodium Sulphate

W.E. KOEPKE

Sodium sulphate (Na_2SO_4), commonly known as 'salt cake', is one of the key raw materials used in the manufacture of pulp and paper by the 'kraft' process. It can be produced from natural deposits and brines in alkaline lakes that occur in areas of little or no drainage and dry climates, from subsurface deposits and brines, or as a byproduct from a number of chemical processes such as the reaction of sodium chloride with sulphuric acid to make hydrochloric acid. Canada's sodium sulphate industry is based on natural brines and deposits in many alkaline lakes in the southern prairies of Saskatchewan and Alberta. Small quantities of byproduct salt cake are recovered at a viscose-rayon plant in Ontario, at a strontium sulphate-carbonate operation in Nova Scotia, and beginning in 1973, it will be recovered from a pulp and paper mill in Ontario.

Elsewhere in North America, naturally occurring sodium sulphate is produced in California, Texas and Wyoming and the byproduct type is produced in the eastern states.

Production and development in Canada

Production (shipments) of sodium sulphate in Canada amounted to 480,000 tons valued at $7.6 million in 1971, down slightly from the previous year. The figures are preliminary and exclude about 15,000 tons of byproduct salt cake recovered at a viscose-rayon plant in Ontario and an estimated 10,000 tons from a strontium sulphate-carbonate operation in Nova Scotia. The lower level of natural sodium sulphate shipments in 1971 is attributed to reduced requirements for makeup sodium sulphate in the pulp and paper manufacturing process stemming from improved technology and greater concern for pollution control. The sluggishness in demand, combined with excess capacity, has resulted in severe competition, with prices being cut as much as 30 per cent towards the end of 1971.

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 runoff 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 thereby accumulating thick deposits of hydrous sodium sulphate, commonly known as Glauber's salt. 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 months are redissolved 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.

Table 1. Canada, sodium sulphate production and trade, 1970-71

	1970		1971^p	
	(short tons)	($)	(short tons)	($)
Production				
Shipments	490,547	7,601,778	480,000	7,640,000
Imports				
Total crude salt cake and Glauber's salt				
United States	16,916	347,000	7,454	150,000
Britain	3,360	73,000	4,059	94,000
Belgium and Luxembourg	8,879	169,000	4,578	87,000
Finland	–	–	5,208	86,000
Total	29,155	589,000	21,299	417,000
Exports				
Crude sodium sulphate				
United States	105,108	2,146,000	112,163	2,198,000
Mozambique	5,719	57,000	10,360	101,000
South Africa	9,059	128,000	–	–
Trinidad-Tobago	2	...	–	–
Total	119,888	2,331,000	122,523	2,299,000

Source: Statistics Canada.
^{p}Preliminary; –Nil; ...Less than one thousand dollars.

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 as much as 9 million tons. One deposit in Alberta contains 3 million tons of Na_2SO_4.

Recovery and processing. For the Saskatchewan producers, weather conditions are equally as important for the recovery of sodium sulphate as for its deposition. A supply of fresh water is also an essential part of recovery.

Sodium sulphate recovery generally begins by pumping concentrated lake brines into reservoirs during the summer months. Pumping takes place when the brine is at the highest degree of 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 in depth, is then excavated using scrapers, shovels or draglines and moved to a stockpile. Stockpiling is done in the winter months and provides sufficient feed to operate a processing plant throughout the year.

Table 2. Canada, sodium sulphate production, trade and consumption, 1962-71

	Production[1]	Imports[2]	Exports	Consumption
	(st)	(st)	(st)	(st)
1962	246,672	31,773	74,049	210,691
1963	256,914	14,497	65,348	238,321
1964	333,263	30,833	107,318	244,592
1965	345,469	29,347	116,345	275,620
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^r
1970	490,547	29,155	119,888	425,071
1971^p	480,000	21,299	122,523	424,000^e

Source: Statistics Canada.
[1]Producers' shipments of crude sodium sulphate.
[2]Includes Glauber's salt and crude salt cake.
^{p}Preliminary; ^{r}Revised; ^{e}Estimated.

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,

Table 3. Canada, natural sodium sulphate plants, 1971

	Plant Location	Source Lake	Annual Capacity
			(st)
Alberta			
Alberta Sulphate Limited	Metiskow	Horseshoe	100,000
Saskatchewan			
Francana Minerals Ltd.	Cabri	Snakehole	100,000
	Alsask[1]	Alsask	50,000
Midwest Chemicals Limited	Palo	Whiteshore	120,000
Ormiston Mining and Smelting Co. Ltd.	Ormiston	Horseshoe	100,000
Saskatchewan Minerals	Chaplin	Chaplin	150,000
Saskatchewan Minerals	Bishopric	Frederick	70,000
Saskatchewan Minerals	Fox Valley	Ingebrigt	150,000
Sybouts Sodium Sulphate Co., Ltd.	Gladmar	East Coteau	50,000
Total			890,000

[1]Inactive.

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-flowing characteristics are important in material handling and use.

The Alberta-based producer uses a solution recovery system rather than the seasonal harvesting method. The raw Glauber's salt is recovered from the lake bed by solution methods, a system which apparently has proven very successful during both summer and winter months. The brine is then subjected to an evaporation and crystallization process to recover the sodium sulphate.

Courtaulds (Canada) Limited produced about 15,000 tons of byproduct salt cake in 1971 from the operation of a viscose-rayon plant at Cornwall, Ontario.

In April 1971, Kaiser Strontium Products Limited, a subsidiary of Kaiser Aluminum & Chemical Canada Limited, began recovering coproduct salt cake at Point Edward, Nova Scotia. In the production process, natural strontium sulphate (celestite) mined at nearby Loch Lomond by Kaiser Celestite Mining Limited is combined with imported, natural sodium carbonate to yield strontium carbonate and sodium sulphate. The plant is designed to produce 100 tons of each compound daily.

Beginning in 1973, Ontario Paper Company Limited is expected to bring on stream an 80-ton-a-day byproduct saltcake recovery unit at its paper mill in Thorold, Ontario.

Canadian consumption

About 94 per cent of the sodium sulphate consumed in Canada is used as a raw material in the production of pulp and paper by the 'kraft' process. The kraft process yields a pulp with a very long fibre that allows manufacture of stronger paper than with other pulps and the process also makes it easier to control pollution at pulp mills. Consumption of sodium sulphate in the pulp and paper industry has increased from 154,000 tons in 1960 to an estimated 400,000 tons in 1971.

Table 4. Canada, available data on sodium sulphate consumption, 1969-71

	1969	1970	1971[e]
	(st)	(st)	(st)
Pulp and paper	414,888[r]	400,000[e]	400,000
Glass and glasswool	7,177	6,268	6,000
Soaps	8,072	9,343	9,000
Other products[1]	6,918	9,460	9,000
Total	437,055	425,071	424,000

Source: Statistics Canada; breakdown by Mineral Resources Branch.
[1]Colours, pigments, foundries, feed supplements and other minor uses.
[e]Estimated; [r]Revised.

Sodium sulphate is also consumed in the manufacture of glass, detergents, mineral-feed supplements, medicinals and a number of other chemical products, and in base-metal smelting.

Outlook

Demand for sodium sulphate in Canada largely hinges upon the needs of the pulp and paper industry and is expected to increase only moderately during the next few years. Some producers had anticipated that larger quantities of sodium sulphate would be consumed by soap and detergent manufacturers following the ban on the use of phosphates, but statistical evidence reveals scarcely any increase in that sector.

For the producers of natural sodium sulphate in western Canada, a moderate increase in total domestic demand implies that output levels are likely to stagnate unless exports can be boosted. Increased quantities of coproduct and byproduct sodium sulphate are becoming available in eastern Canada and are capturing part of the market previously served from Saskatchewan. Since the Alberta producer has a modern, efficient plant and a slight freight advantage over the Saskatchewan plants in serving foothills and west coast markets, much of the burden of excess capacity will continue to fall on Saskatchewan producers; one might expect further rationalization of the Saskatchewan industry.

Tariffs

Canada

Item No.		
21000-1	Natural sodium sulphate	
	British Preferential	10%
	Most Favoured Nation	15%
	General	25%

United States

Item No.		
421.42	Crude (salt cake)*	free

		On and After Jan. 1, 1969	On and After Jan. 1, 1970	On and After Jan. 1, 1971	On and After Jan. 1, 1972
		(cents per long ton)			
421.44	Anhydrous	40	35	30	25
421.46	Crystallized (Glauber's salt)*	80	70	60	50

Sources: The Custom Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa. Tariff Schedules of the United States, Annotated, 1971, TC Publication 344.
*Note: Rates of duty for 1970, 1971 and 1972 were to become effective unless the European Economic Community and Britain had not proceeded with certain reductions provided for in their respective schedules annexed to the Geneva (1967) Protocol to GATT. These two participants have not so proceeded, and the President has proclaimed that the rate of duty under 1969 will continue in effect until the President proclaims that the two participants have agreed to proceed with reductions.

Prices

Canadian prices of sodium sulphate, as quoted by Canadian Chemical Processing, Buyers Guide, December 1971

	(Can. $ per short ton)
Sodium sulphate (salt cake)	
Bulk, carlots, fob works	16.50
Detergent-grade bulk, fob works	20.50

United States prices according to Oil, Paint and Drug Reporter, December 27, 1971

	(U.S. $ per short ton)
Salt cake, 100% Na_2SO_4 basis fob works	28
Salt cake, domestic, West, bulk, carlots, fob producing point	18.50
Sodium sulphate, detergent, rayon-grade, carlots, fob works, bulk	
East	40 – 43
West	33 – 34

Quoted prices for the year-end were down from $1.50 to $3 a ton from the previous year's close, but rumours were that towards the end of 1971, sodium sulphate was being sold as low as $11.50 a ton fob plant, Saskatchewan.

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 that which 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.

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, while 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 stones.

Crushed stone

Crushed stone accounts for over 80 per cent of stone production. Many quarries which produce crushed stone are operated primarily to produce stone for other purposes – 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.

Rehabilitation of a stone quarry to permit subsequent land use is generally more difficult and costly than for gravel pits. They do provide the same disruptions to the natural environment and to urban development and are therefore included in continuing studies to plan efficient land use. Justifiable concern has been shown relative to the future development, operation and rehabilitation of pits and quarries in all locations, specifically in and near districts where urban development is surrounding quarry sites and overrunning potential sources of raw mineral materials used by the construction industry. Master plans are required to co-ordinate all phases of development and to

Table 1. Canada, total production (shipments) of stone, 1969, 1970 and 1971

	1969		1970		1971ᵖ	
	(short tons)	($)	(short tons)	($)	(short tons)	($)
By province						
Newfoundland	189,929	338,703	182,400	282,600	100,000	100,000
Prince Edward Island	–	–	–	–	–	–
Nova Scotia	1,015,901	2,406,638	1,191,998	2,254,267	900,000	1,800,000
New Brunswick	1,208,512	2,153,359	1,321,454	2,773,433	1,300,000	2,600,000
Quebec	32,008,732	39,312,048	30,143,792	38,580,761	30,200,000	38,800,000
Ontario	27,034,506	32,293,526	27,673,376	34,447,188	27,500,000	35,300,000
Manitoba	699,123	2,010,398	1,272,690	3,198,305	1,100,000	2,500,000
Alberta	314,701	1,097,982	166,147	612,506	200,000	700,000
British Columbia	5,005,608	8,573,608	3,370,983	5,826,690	3,500,000	6,300,000
Canada	67,477,012	88,186,262	65,322,840	87,975,750	64,800,000	88,100,000
By use						
Building stone						
Rough	55,356	1,330,667	46,103	1,324,850		
Dressed	51,159	4,700,671	42,163	3,943,439		
Monumental and ornamental stone						
Rough	23,454	860,502	22,568	902,511		
Dressed	8,082	1,292,089	6,093	1,044,057		
Flagstone	8,316	53,458	8,293	27,237		
Curbstone	8,487	211,717	6,269	162,833		
Paving blocks	416	4,995	100	6,600		
Chemical and metallurgical						
Cement plants, foreign	1,151,792	1,220,420	1,224,026	1,356.889		
Lining, open-hearth furnaces	271,728	178,873	348,052	217,344		
Flux in iron and steel furnaces	1,533,782	1,874,574	1,511,037	1,768,269		
Flux in nonferrous smelters	119,482	133,010	174,974	178,449		
Glass factories	158,880	472,401	205,710	766,237		
Lime kilns, foreign	261,725	469,467	114,575	291,742		
Pulp and paper mills	372,609	1,102,549	328,265	1,145,773		
Sugar refineries	100,478	222,223	87,866	214,632		
Other chemical uses	677,965	822,344	710,407	936,196		
Pulverized stone						
Whiting (substitute)	199,438	393,080	138,595	168,576		
Asphalt filler	467,595	779,570	410,826	703,484		
Dusting coal mines	6,062	32,755	8,599	36,867		
Agricultural purposes and fertilizer plants	840,664	2,335,449	936,555	2,851,295		
Other uses	336,219	589,975	350,597	668,361		
Crushed stone						
For manufacture of artificial stone	85,348	279,536	179,723	434,863		
Roofing granules	93,185	1,764,717	90,994	1,854,570		
Poultry grit	19,273	139,382	17,624	194,672		
Stucco dash	13,165	370,276	9,961	278,295		
Terrazzo chips	12,743	230,954	14,346	283,203		
Rock wool	7,741	33,629	1,039	1,350		
Rubble and riprap	3,538,547	3,348,993	1,663,490	1,852,626		
Concrete aggregate	12,230,784	14,822,419	10,985,693	13,010,302		
Road metal	30,068,306	31,702,630	22,093,020	23,486,605		
Railroad ballast	2,449,038	3,581,999	4,666,820	5,394,266		
Other uses	12,305,193	12,830,938	18,918,457	22,469,357		
Total	67,477,012	88,186,262	65,322,840	87,975,750		

Source: Statistics Canada. ᵖPreliminary; – Nil.

provide for optimum utilization of these nonrenewable resources. In Ontario, the Niagara Escarpment Protection Act, June 26, 1970, prohibits future mining on the escarpment face and for 300 feet back from the face. Regulations outlining requirements for licensing gravel pits and quarries, as well as standards for the rehabilitation of pit and quarry lands, were approved by the Ontario Government on December 22, 1971.

Crushed stone uses include: the manufacture of roofing granules from granite and marble, the production of poultry grit from limestone 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; limestone and marble for agricultural application. Also, in excess of 3.5 million tons of limestone is produced for chemical and metallurgical uses in the iron and steel industry, the glass industry, the pulp and paper industry and in sugar manufacture.

Stone production in Canada, either as dimension stone or as crushed stone, is used either directly or indirectly by the construction industry. 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.

*Construction Spending by Province**

	1970	1971ᵖ	1972ᵉ
	(millions of dollars)		
Newfoundland	416	540	594
Prince Edward Island	45	57	67
Nova Scotia	485	466	526
New Brunswick	339	350	391
Quebec	2,789	3,253	3,518
Ontario	4,985	5,623	5,759
Manitoba	695	697	765
Saskatchewan	475	524	542
Alberta	1,709	1,764	1,828
British Columbia	1,732	2,221	2,155
Yukon and N.W.T.	110	152	195
Canada	13,780	15,647	16,340

*Source: Statistics Canada. ^{p}Preliminary; ^{e}Estimated.

Canadian industry

Atlantic provinces. *Limestone.* At Corner Brook, Newfoundland, Westland Equipment quarried a high-calcium limestone for use by Bowaters Newfoundland Limited in the calcium-acid sulphite process of pulp preparation. About 20,000 tons a year is used.

Mosher Limestone Company Limited quarried a dolomitic limestone at Upper Musquodoboit, Nova Scotia. Some crushed material was shipped by rail to the steel works at Sydney, Nova Scotia, and pulverized material was sold for agricultural use throughout the Atlantic provinces. Sydney Steel Corporation produced a high-calcium, fossiliferous limestone at Irish Cove, Nova Scotia, and a high-purity dolomite at Frenchvale, Nova Scotia, both for use in the Sydney steel plant. A quarry providing sized limestone to Scott Paper Limited at Abercrombie, Nova Scotia, was begun in 1968 near Antigonish Harbour by Calpo Limited. Extensive exploration for and assessment of limestones in Nova Scotia continues to provide mineral inventory data for prospective consumers.

In New Brunswick, limestone was quarried at three locations – Brookville, Elm Tree and Havelock – for use as a crushed stone, as an aggregate, or for agricultural application.

There are three cement producers and two lime manufacturing plants in the Atlantic provinces, each operating its own limestone quarry. Reference should be made to the Cement and Lime sections of the *Canadian Minerals Yearbook 1971.*

Granite. 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, while a black granite from Shelburne and a diorite from Erinville are used as facing stone. In 1971 there was no production from old granite quarries in the Halifax, New Germany or Queensport areas. Quartzitic rock referred to as "bluestone" was quarried at Lake Echo, north of Dartmouth, for use as facing stone.

In New Brunswick, a coarse-grained, grey-brown granite was quarried near St. Stephen, and fine-grained, pink, grey and blue-grey granites were available in the Hampstead (Spoon Island) district. In the Bathurst area, a brown-to-grey, coarse-grained granite was quarried upon demand, as was a salmon-coloured, medium-grained granite near Antinouri Lake, and a black, ferromagnesian rock in the Bocabec River area. Red granite was available in the St. George district.

Sandstone. A medium-grained, buff-coloured, sandstone was quarried at Wallace, Nova Scotia, in 1971, 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 of the Mount Allison University campus. A number of deposits are exploited from time to time throughout Kent and Westmorland counties for local projects and for highway work.

Quebec. *Limestone.* Limestone occurs in the St. Lawrence and Ottawa river valleys and in the Eastern

Table 2. Canada, production (shipments) of limestone, 1969-70

	1969		1970	
	(short tons)	($)	(short tons)	($)
By provinces				
Newfoundland	83,929	124,308	82,400	82,600
Nova Scotia	383,784	975,326	325,897	807,609
New Brunswick	300,877	749,774	285,283	912,286
Quebec	28,052,715	28,071,916	26,687,935	28,295,310
Ontario	26,202,850	28,638,664	26,517,386	30,428,000
Manitoba	698,683	1,690,448	913,824	1,816,995
Alberta	313,751	1,063,284	166,147	612,506
British Columbia	3,573,767	5,905,283	2,917,425	4,608,484
Canada	59,610,356	67,219,003	57,896,297	67,563,790
By use				
Building stone				
Rough	13,577	165,122	5,982	57,907
Dressed	29,301	1,060,228	23,222	867,632
Monumental and ornamental				
Rough	1,105	25,259	1,704	41,136
Dressed	739	5,912	1,063	13,824
Flagstone	6,850	16,351	8,084	21,037
Curbstone	12	36	579	5,700
Paving blocks	–	–	100	6,600
Chemical and metallurgical				
Cement plants, foreign	1,151,792	1,220,420	1,184,088	1,272,621
Lining, open-hearth furnaces	271,728	178,873	348,052	217,344
Flux, iron and steel furnaces	1,533,782	1,874,574	1,511,037	1,768,269
Flux, nonferrous smelters	119,482	133,010	174,974	178,449
Glass factories	158,880	472,401	205,710	766,237
Lime kilns, foreign	261,725	469,467	114,575	291,742
Pulp and paper mills	372,609	1,102,549	328,165	1,074,557
Sugar refineries	100,478	222,223	87,866	214,632
Other chemical uses	677,965	822,344	710,407	936,196
Pulverized stone				
Whiting substitute	199,438	393,080	138,595	168,576
Asphalt filler	343,108	532,037	289,547	483,325
Dusting coal mines	6,062	32,755	8,599	36,867
Agricultural purposes and fertilizer plants	825,329	2,303,319	922,625	2,821,001
Other uses	336,219	589,975	349,327	662,011
Crushed stone				
For artificial stone	55,091	208,767	163,723	408,343
Roofing granules	5,655	25,464	3,495	23,216
Poultry grit	15,480	112,023	10,800	108,224
Stucco dash	13,165	370,276	9,961	278,295
Terrazzo chips	200	1,200	210	1,260
Rock wool	1,242	1,134	1,039	1,350
Rubble and riprap	3,104,627	2,845,528	928,301	1,022,154
Concrete aggregate	10,286,625	11,094,338	9,241,866	9,679,351
Road metal	26,208,450	26,721,742	19,142,421	19,189,607
Railroad ballast	2,036,953	2,477,974	3,997,711	4,260,231
Other uses	11,472,687	11,740,622	17,982,469	20,686,096
Total	59,610,356	67,219,003	57,896,297	67,563,790

Source: Statistics Canada. – Nil.

Table 3. Canada, production (shipments) of marble, 1969-70

	1969		1970	
	(short tons)	($)	(short tons)	($)
By provinces				
Quebec	76,363	175,124	53,365	127,279
Ontario	9,485	215,475	8,470	223,624
Total, Canada	85,848	390,599	61,835	350,903
By use				
Building stone				
Rough	420	15,500	–	–
Dressed	140	9,600	–	–
Pulverized stone				
Whiting substitute	–	–	–	–
Agricultural purposes and fertilizer plants	15,335	32,130	13,571	28,499
Other uses	–	–	–	–
Crushed stone				
For manufacture of artificial stone	5,257	20,769	–	–
Roofing granules	5,383	26,346	–	–
Poultry grit	–	–	–	–
Stucco dash	–	–	–	–
Terrazzo chips	12,082	228,094	13,473	279,611
Rock wool	–	–	–	–
Concrete aggregate	15,687	19,320	2,665	3,278
Road metal	31,544	38,840	32,038	39,407
Other uses	–	–	88	108
Total	85,848	390,599	61,835	350,903

Source: Statistics Canada. – Nil.

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 in geological age from Precambrian to Carboniferous, and vary widely in purity, colour, texture and chemical composition.

Of over 90 limestone producers in Quebec, about 50 were classed as stone quarries with non-cement, non-lime associations. These were located near major market areas such as Montreal, Quebec, Sherbrooke, Ottawa-Hull and Trois-Rivières and supplied crushed stone to the construction industry mainly for use in concrete and asphalt and as highway subgrade. Between 70 and 80 per cent of all stone quarried in Quebec was limestone, of which about 85 per cent was used as a crushed stone.

The pulp and paper industry, the metallurgical industry and the agricultural industry each used substantial quantities of limestone. At Kilmar, in western Quebec, Dresser Industries Canada, Ltd., formerly Canadian Refractories Limited mined a magnesite-dolomite ore from which it produced refractory-grade magnesia and magnesia products.

Six companies operated a total of seven cement manufacturing plants in Quebec while lime was produced by four companies at four locations. (See Cement and Lime sections of the *Canadian Minerals Yearbook 1971*).

A fine-grained, brownish grey, fossiliferous limestone is available in the St-Marc-des-Carrières region of Quebec. It has been estimated that 1.7 million tons of crushed stone will be required for the first stage of runway construction at the new Montreal International Airport complex at Ste-Scholastique. A fine-grained dolomite, meeting the Department of Transport specifications, is being quarried near the site by TRP Quarries Limited, Montreal under contract for Montcalm Construction, Brampton, Ontario from a deposit with proven reserves of 30 million cubic yards.

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.

Granite. Nearly 60 per cent of Canada's granite production comes from Quebec from long-established operations in two general regions – the region north of the St. Lawrence and Ottawa rivers, including the Lac Saint-Jean area, and the region south of the St.

Table 4. Canada, production (shipments) of granite, 1969-70

	1969		1970	
	(short tons)	($)	(short tons)	($)
By provinces				
Nova Scotia	11,092	139,194	157,131	182,328
New Brunswick	905,320	1,298,568	1,016,553	1,740,097
Quebec	2,386,712	8,984,478	1,807,475	7,752,217
Ontario	769,407	2,962,757	1,128,364	3,559,700
Manitoba	440	319,950	358,866	1,381,310
British Columbia	1,326,841	2,127,213	368,850	616,239
Total Canada	5,399,812	15,832,160	4,837,239	15,231,891
By use				
Building stone				
Rough	17,600	633,539	21,981	942,137
Dressed	21,368	3,603,727	11,921	2,934,302
Monumental and ornamental				
Rough	21,399	800,545	20,864	861,375
Dressed	7,343	1,286,177	5,030	1,030,233
Flagstone	10	190		
Curbstone	8,125	199,181	5,190	151,235
Paving blocks	–	–	–	–
Chemical uses				
Pulp and paper mills			100	71,216
Pulverized				
Asphalt filler	8,487	15,533	3,279	9,169
Other pulverized uses	–	–	–	–
Crushed stone				
For artificial stone	–	–	16,000	26,520
Roofing granules	78,642	1,703,726	79,234	1,812,082
Poultry grit	978	11,736	4,477	73,540
Stucco dash	–	–	–	–
Rubble and riprap	431,253	493,976	692,934	792,449
Concrete aggregate	1,120,291	1,998,904	1,001,042	1,668,426
Road metal	2,690,005	3,379,653	1,860,701	2,910,502
Railroad ballast	208,796	700,488	243,601	297,898
Other uses	785,515	1,004,785	870,885	1,650,807
Total	5,399,812	15,832,160	4,837,239	15,231,891

Source: Statistics Canada. – Nil.

Table 5. Canada, production (shipments) of sandstone, 1969-70

	1969		1970	
	(short tons)	($)	(short tons)	($)
By provinces				
Newfoundland	106,000	214,395	100,000	200,000
Nova Scotia	621,025	1,292,118	708,970	1,264,330
New Brunswick	2,315	105,017	13,271	67,171
Quebec	1,492,942	2,080,530	1,487,110	2,366,343
Ontario	52,764	476,630	19,156	235,864
Alberta	950	34,698	–	–
Canada	2,275,996	4,203,388	2,328,957	4,133,708

Table 5 (concl.)

	1969		1970	
	(short tons)	($)	Short tons)	($)
By use				
Building stone				
Rough	23,759	516,506	18,140	324,806
Dressed	350	27,116	7,020	141,505
Monumental and ornamental rough	950	34,698	–	–
Flagstone	1,456	36,917	209	6,200
Curbstone	350	12,500	500	5,898
Paving blocks	416	4,995	–	–
Pulverized stone				
Asphalt filler	116,000	232,000	118,000	210,990
Agricultural purposes and fertilizer plants			359	1,795
Crushed stone				
For artificial stone	25,000	50,000	–	–
Roofing granules	3,505	9,181	8,265	19,272
Poultry grit	2,815	15,623	2,347	12,908
Stucco dash	–	–	–	–
Terrazzo chips	461	1,660	663	2,332
Rock wool	6,499	32,495	–	–
Rubble and riprap	2,667	9,489	42,255	38,023
Concrete aggregate	703,181	1,168,745	690,723	1,094,019
Road metal	1,138,307	1,562,395	949,953	1,307,477
Road ballast	203,289	403,537	425,508	836,137
Other uses	46,991	85,531	65,015	132,346
Total	2,275,996	4,203,388	2,328,957	4,133,708

Source: Statistics Canada. – Nil.

Table 6. Canada, production (shipments) of shale, 1969-70

	1969		1970	
	(short tons)	($)	(short tons)	($)
By province				
New Brunswick	–	–	5,897	53,879
Quebec	–	–	107,907	39,612
British Columbia	105,000	541,112	84,708	601,967
Canada	105,000	541,112	198,512	695,458
By use				
Chemical and metallurgical				
Cement plants, foreign	–	–	39,938	84,268
Other chemical uses	–	–	–	–
Pulverized				
Other uses	–	–	1,270	6,350
Crushed stone				
Concrete aggregate	105,000	541,112	49,397	565,228
Road metal	–	–	107,907	39,612
Rail and ballast	–	–	–	–
Other uses	–	–	–	–
Total	105,000	541,112	198,512	695,458

Source: Statistics Canada. – Nil.

Lawrence River, in the Eastern Townships. North of the St. Lawrence River, Precambrian rocks contain granites of various colours, compositions and textures: red, brown, pink and black granites in the Lac Saint-Jean area; a fine-grained pink granite and a black anorthositic rock near Alma, and in the St-Luger-de-Milot area; coarse-grained, blue-grey and dark green granites at Rivière-à-Pierre; black and grey gneissic rocks at Rivière-à-Pierre and at Notre-Dame-des-Anges; red-pink granite at St-Alban and a banded, pink-red gneiss at St-Raymond; fine-grained, pink-coloured granite in the Laurier-Guenette area and a grey-pink gneiss at L'Annonciation; an augen-type granite near Mont-Tremblant and a coarse-grained, brown granite in the St-Alexis-des-Monts area; grey-speckled, black and gabbroic rock in the Montpellier area and a dark-coloured anorthositic rock in the Rouyn area; brown-red to green-brown syenites in the Grenville district, a mauve-red granite in the Ville-Marie area on Lake Timiskaming. Many areas underlain by granite are too remote from transportation and markets to be economically attractive.

In the region south of the St. Lawrence River, granites are much younger and are essentially greyish.

Sandstone. There were 14 mining operations in Quebec in which sandstone was being quarried for construction uses. The material was used as a facing stone and as an aggregate. Deposits in the vicinity of Trois-Pistoles and near Quebec City are available for exploitation.

Ontario. *Limestone.* Although limestones in Ontario range from Precambrian through Devonian in age, the major production comes from Ordovician, Silurian and Devonian deposits. 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 limestones extending from Fort Erie through London and Woodstock to Lake Huron. Production of building stone, fluxstone

Table 7. Canada, production (shipments) of stone by types, 1961-71

	Granite		Limestone		Marble		Sandstone	
	(short tons)	($)	(short tons)	($)	(short tons)	($)	(short tons)	($)
1961	6,355,734	14,162,206	38,152,775	47,183,610	67,643	775,949	4,226,299	4,078,777
1962	5,386,880	13,942,156	41,551,585	50,315,116	71,888	707,724	3,492,071	3,735,957
1963	5,679,264	15,070,882	51,021,396	58,053,321	71,714	755,889	5,732,276	5,776,107
1964	7,310,629	16,854,742	57,019,890	63,140,728	95,455	891,617	4,433,555	5,264,849
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
1971p	..	..	..	..	..	..	..	..

	Shale		Slate		Total	
	(short tons)	($)	(short tons)	($)	(short tons)	($)
1961	135,103	365,376	1,250	1,750	48,938,804	66,567,668
1962	45,686	149,684	5,375	15,721	50,553,485	68,866,358
1963	104,130	199,070	46,549	28,150	62,655,329	79,883,419
1964	743,564	621,197	191,265	109,550	69,794,358	86,882,683
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
1971p	..	..	..	..	64,800,000	88,100,000

Source: Statistics Canada. pPreliminary; .. Not available; – Nil.

and crushed aggregate from the limestones of these areas amounted to over 90 per cent of total stone production in Ontario during 1971.

Marble, ranging in colour from blue to pink, has been quarried for construction purposes from deposits near Perth. Marble is widely distributed over southeastern Ontario and according to Ontario Department of Mines reports, underlies as much as 100 square miles.

The limestone industries of Ontario are described in detail in publications of the Ontario Department of Mines.

Eight companies operated a total of ten lime-producing facilities in Ontario in 1971 and four companies produced portland cement at a total of six locations. (See Cement and Lime sections of the *Canadian Minerals Yearbook 1971*.) Crushed stone was shipped from most of these plants.

Granite. Granites occur in northern, northwestern and southeastern Ontario. Few deposits have been exploited for the production of building stone because the major consuming centres are in south and southwestern Ontario, where ample, good-quality limestones and sandstones are readily available for building purposes. 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. 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 are also mottled. They are fine-to-medium-grained. The Potsdam stone is medium-grained and the colour ranges from grey-white through salmon-red to purple and it also can be mottled. Current uses are as rough building stone, mill blocks from which sawn pieces are obtained, ashlar and flagstone.

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. Although building stone does not account for a large percentage of total limestone produced, perhaps the best known of the Manitoba limestones is Tyndall Stone, a mottled dolomitic limestone often referred to as "tapestry" stone. It has found wide acceptance 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 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, for the pulp and paper, cement and lime industries has been investigated.

The eastern ranges of the Rocky Mountains contain limestones 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. 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.

In British Columbia, large volumes of limestone are mined each year for cement manufacture, for use by the pulp and paper industry and for various construction applications. A large amount is exported to northwestern United States for cement and lime manufacture. Four companies mined limestone on Texada Island with the entire output being moved by barge to Vancouver and to the State of Washington. Other operations at Terrace, Clinton, Westwold, Popkum, Dahl Lake, Koeye River and Cobble Hill produced stone for construction use, for filler use, and cement manufacture. Beginning in 1969, shipments of limestone from a new quarry on Aristazabal Island, 350 miles north of Vancouver, were made to the Portland, Oregon area by Laredo Limestone Ltd. During 1971 interest was revived in the possible use of travertine from a British Columbia source.

Eight cement plants and seven lime plants were operated in western Canada in 1971. (See Cement and Lime sections of the *Canadian Minerals Yearbook 1971*.)

Granite. In Manitoba, at Lac du Bonnet northeast of Winnipeg, a durable, red granite was quarried for building and monumental use. Grey granite 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".

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.

Over 70 per cent of Canada's annual production of limestone is used as a crushed stone. This includes about 50 per cent used as road metal (broken, screened stone for macadam roads), about 20 per cent used as concrete aggregate and about 2 per cent used 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 a 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 refactory, is produced at Dundas, Ontario.

Table 8. Canada, stone imports and exports, 1969-71

	1969		1970		1971p	
	(short tons)	($)	(short tons)	($)	(short tons)	($)
Exports						
Building stone, rough	21,308	901,000	21,062	889,000	19,230	869,000
Natural stone basic products	..	2,175,000	..	3,215,000	..	2,879,000
Total		3,076,000		4,104,000		3,748,000
Imports						
Stone, crude, nes	1,121	53,000	2,377	49,000	2,185	32,000
Building stone, rough, nes	15,307	571,000	14,697	528,000	13,145	535,000
Granite, rough	14,271	665,000	13,048	567,000	13,254	549,000
Marble, rough	6,445	569,000	4,676	378,000	2,199	275,000
Shaped or dressed granite	..	548,000	..	408,000	..	1,161,000
Shaped or dressed marble	..	542,000	..	666,000	..	785,000
Natural stone basic products, nes	..	281,000	..	195,000	..	216,000
Total		3,229,000		2,791,000		3,553,000

Source: Statistics Canada. pPreliminary; .. Not available; nes Not elsewhere specified.

Table 9. Value of construction in Canada, 1970-72

	1970	1971	1972[1]	Change 1971-72
	(millions of dollars)			%
Building construction				
Residential	4,008.5	4,828.0	5,183.7	+7.4
Industrial	1,000.2	1,027.6	908.3	−11.6
Commercial	1,286.6	1,344.9	1,475.4	+9.7
Institutional	1,330.2	1,474.0	1,446.6	−1.9
Other building	472.8	469.0	457.4	−2.5
Total	8,098.3	9,143.5	9,471.4	+3.6
Engineering construction				
Marine	144.7	145.5	200.5	+37.8
Highways, aerodromes	1,280.3	1,422.4	1,510.5	+6.2
Waterworks sewage systems	487.7	629.3	664.5	+5.6
Dams, irrigation	58.2	78.2	69.0	−11.8
Electric power	1,223.6	1,307.6	1,281.6	−2.0
Railways, telephones	568.3	608.0	638.6	+5.0
Gas, oil facilities	1,093.6	1,302.1	1,384.7	+6.3
Other engineering	826.5	1,010.8	1,120.1	+10.8
Total	5,682.9	6,503.9	6,869.5	+5.6
Total construction	13,781.2	15,647.4	16,340.9	+4.4

Source: Statistics Canada. [1]Intentions.

Limestone from deposits in coastal areas of British Columbia is mined, crushed, loaded to 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, through 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 in Canada in the near future 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.

Trade, mostly with the United States, is minimal and probably takes place in immediate border regions where transportation costs rather than quality of material are the main reason for use of a foreign material.

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 elsewhere, 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 in the near future. 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.

Table 10. Canada, value of construction work performed by principal type of construction, by industry, 1969-72

Industry	1969			1970			1971			1972[1]		
	Building	Engi-neering	Total	Building	Engi-neering	Total	Building	Engi-neering	Total	Building	Engi-neering	Total
	(millions of dollars)											
Agriculture and fishing	225	121	346	204	110	314	204	110	314	202	110	312
Forestry	10	58	68	7	56	63	5	54	59	7	62	69
Mining, quarrying oil wells	201	807	1,008	165	968	1,133	297	1,127	1,424	248	1,114	1,362
Construction	20	–	20	21	–	21	22	–	22	24	–	24
Manufacturing	682	295	977	851	360	1,211	723	361	1,084	618	417	1,035
Utilities	214	1,858	2,072	263	2,158	2,421	209	2,510	2,719	212	2,671	2,883
Trade	251	13	264	278	10	288	224	8	232	247	11	258
Finance, insurance, real estate	433	8	441	455	7	462	502	10	512	534	19	553
Commercial services	130	1	131	149	4	153	196	1	197	235	1	236
Housing	4,228	–	4,228	4,009	–	4,009	4,828	–	4,828	5,184	–	5,184
Institutional services	1,228	10	1,238	1,186	13	1,199	1,284	13	1,297	1,246	14	1,260
Government departments	434	1,980	2,414	510	1,997	2,507	649	2,310	2,959	714	2,451	3,165
Total	8,056	5,151	13,207	8,098	5,683	13,781	9,143	6,504	15,647	9,471	6,870	16,341

Source: Statistics Canada.
[1] Intentions; – Nil.

Tariffs

Canada

Item No.		British Preferential	Most Favoured Nation	General
		(%)	(%)	(%)
29635–1	Limestone, not further processed than crushed or screened	free	free	25
30500–1	Flagstone, sandstone and all building stone, not hammered, sawn or chiselled	free	free	20
30505–1	Marble, rough, not hammered or chiselled	10	10	20
30510–1	Granite, rough, not hammered or chiselled	free	free	20
30515–1	Marble, sawn or sand rubbed, not polished	free	10	35
30520–1	Granite, sawn	free	10	35
30525–1	Paving blocks of stone	free	7½	35
30530–1	Flagstone and building stone, other than marble or granite, sawn on not more than two sides	free	7½	35
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
30610–1	Building stone, other than marble or granite planed, turned, cut or further manufactured than sawn on four sides	7½	12½	15
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
30700–1	Marble, nop	17½	17½	40
30705–1	Manufactures of marble, nop	17½	17½	40
30710–1	Granite, nop	17½	17½	40
30715–1	Manufacturers of granite, nop	17½	17½	40
30800–1	Manufacturers of stone, nop	17½	17½	35
30905–1	Granules, whether or not coloured or coated, for use in manufacture of roofing, including shingles and siding	free	free	25
30900–1	Roofing slate, per square of 100 square feet	free	free	75¢

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: The Custom Tariff and Amendments, Department of National Revenue, Customs and Excise Division. Tariff Schedules of the United States, Annotated (1971) T.C. Publication 344.
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 states. 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 one 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 reached an estimated 45.4 million metric tons in 1971, exceeding demand for the fourth consecutive year. Western world production rose to 30.5 million metric tons and consumption, in keeping with the long-term historical growth rate, increased 4 per cent over 1970 to reach 30.6 million metric tons. Poland's Frasch sulphur sales into world markets have grown rapidly since they began in 1965. Polish sales into western markets increased from 1.34 million metric tons in 1970 to an estimated 1.75 million metric tons in 1971 and, as a result, other producers' stockpiles, notably in Canada, continued to mount.

Prices, which have been declining since mid-1968 under the pressure of oversupply, diminished still further during 1971. In spite of falling prices, Canada's total elemental sulphur sales decreased 14 per cent from 1970. Other world producers showed modest to large sales gains and competition continues to be keen.

International discussion (initiated by Canada in 1971) arising out of concern by government for problems created by excessive production, and the attention being focussed on research and development of new uses for sulphur, will hopefully lead to ultimate long-term solutions. In the near term, however, world stocks will continue to increase throughout the seventies.

The Canadian sulphur industry

Numerous native sulphur occurrences in Canada have received attention in the past but none of commercial importance has been outlined. 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 which are 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. Eighty per cent of Canadian sulphur shipments in 1971 were in elemental form, almost totally derived from sour natural gas in western Canada.

Dramatic growth over the last 10 years in the Canadian sulphur industry is due almost entirely to expanded exploitation and treatment of sour natural gas, principally in Alberta. Canadian production of sulphur in all forms in 1960 was one million long tons, elemental sulphur making up only one quarter of the total. In 1971, total sulphur production is estimated at 5.2 million long tons, some 4.5 million tons in elemental form. Although Canada grew to be the

Table 1. Canada, sulphur production and trade, 1970-71

	1970		1971^p	
	(short tons)	($)	(short tons)	($)
Production (shipments)				
Pyrite and pyrrhotite[1]				
Gross weight	362,669		318,000	
Sulphur content	175,523	1,699,474	154,000^e	1,186,000
Sulphur in smelter gases[2]	705,876	7,433,101	676,000	5,106,000
Elemental sulphur[3]	3,548,310	28,353,509	3,065,000	20,771,000
Total sulphur content	4,429,709	37,486,084	3,895,000	27,063,000
Imports				
Sulphur, crude or refined				
United States	53,455	1,468,000	30,782	745,000
Exports				
Sulphur in ores (pyrite)				
United States	..	1,118,000	..	1,074,000
Japan	..	108,000	..	–
Total	..	1,226,000	..	1,074,000
Sulphur, crude or refined, nes				
United States	1,180,301	16,773,000	1,008,458	10,417,000
Australia	220,246	3,447,000	246,398	2,848,000
New Zealand	180,187	3,250,000	170,506	2,526,000
Belgium-Luxembourg	45,071	168,000	285,432	2,177,000
India	383,017	6,285,000	165,847	1,697,000
Italy	90,408	1,420,000	117,875	1,520,000
Taiwan	234,323	3,312,000	118,819	1,222,000
South Korea	158,381	1,744,000	142,357	1,063,000
Britain	195,683	2,785,000	74,463	870,000
Netherlands	56,330	890,000	44,912	581,000
Other countries	244,485	2,787,000	272,826	2,211,000
Total	2,988,432	42,861,000	2,647,893	27,132,000

Source: Statistics Canada.
[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 oils and from the treatment of nickel-sulphide matte.
^{p}Preliminary; – Nil; .. Not available; nes Not elsewhere specified; ^{e} Estimated.

world's largest supplier in 1968, events took a dramatic downturn in 1971 with a substantial drop in sales. As a result, Canada's growing stockpile reached an estimated 5.4 million long tons in 1971. Previous production estimates of around 6 million tons for 1971 were not realized because of delays in bringing new plants on stream.

Canadian sulphur shipments in all forms in 1971 amounted to 3,895,000 short tons valued at $27,063,000. This represents a tonnage decrease of 14 per cent and a value decrease of 28 per cent compared to 1970. The downward pressure on sulphur prices due to world oversupply continued throughout 1971, the average price for the year dropping to $7.22 a long ton fob Alberta plant. An all-time low monthly average of $5.47 per ton was reached in December.

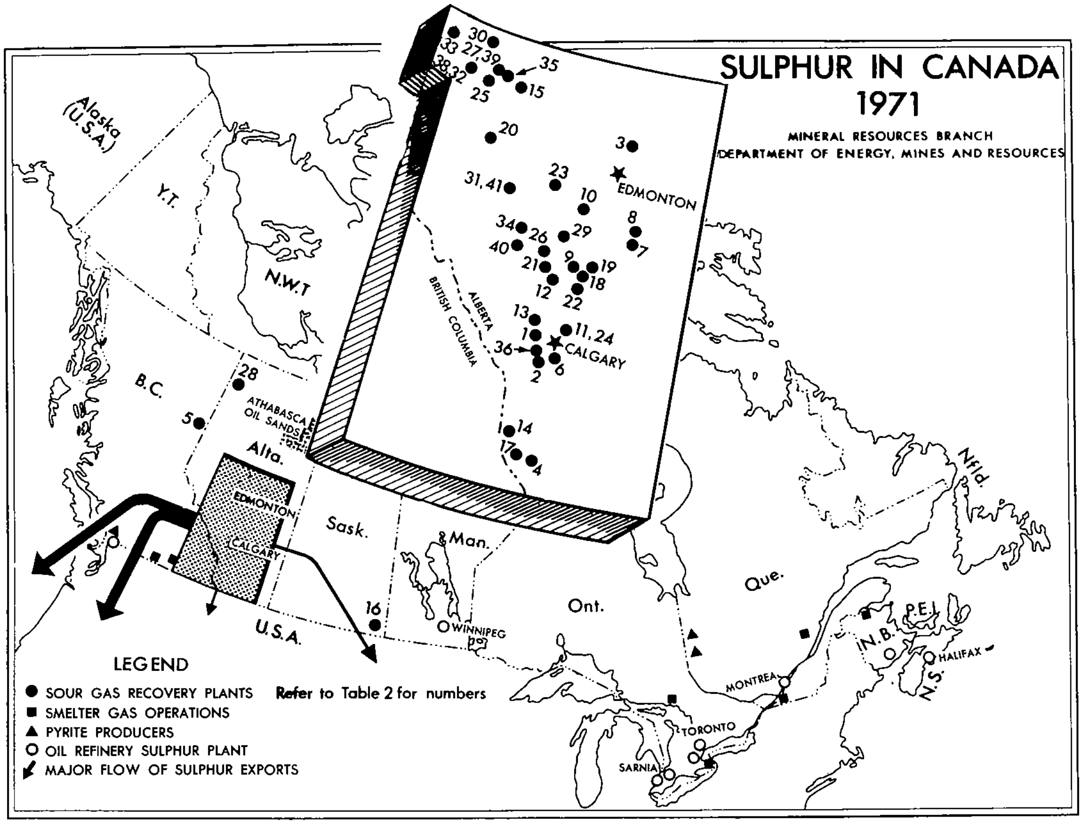
Hydrocarbon sources

Hydrocarbons contain sulphur in some form in at least minute amounts. When the sulphur content becomes unacceptably high it must be removed. Sulphur recovered from sour natural gas is presently the most important source in Canada. It occurs as hydrogen sulphide (H_2S) in varying quantities in many gas reservoirs in western Canada. Because of hydrogen sulphide's corrosive and toxic nature it must be

Table 2. Canada, sour gas sulphur extraction plants, 1971

Operating Company	Source Field or Plant Location	H_2S in Raw Gas	Daily Capacity
		(%)	(long tons)
1. Shell Canada	Jumping Pound, Alta.	3-5	420
2. Gulf Oil Canada	Turner Valley, Alta.	4	35
3. Imperial Oil	Redwater, Alta.	3	21
4. Gulf Oil Canada	Pincher Creek, Alta.	10	675
5. Canadian Occidental	Taylor Flats, B.C.	3	320
6. Texas Gulf Sulphur	Okotoks, Alta.	33	430
7. Gulf Oil Canada	Nevis, Alta.	3-7	198
8. Chevron Standard	Nevis, Alta.	7	204
9. Shell Canada	Innisfail, Alta.	14	115
10. Gulf Oil Canada	Rimbey, Alta.	1-3	328
11. Petrogas Processing	Crossfield, Alta.	31	1,970
12. Home Oil	Carstairs, Alta.	1	42
13. Canadian Fina Oil	Wildcat Hills, Alta.	4	137
14. Canadian Occidental	Savannah Creek, Alta.	13	381
15. Texas Gulf Sulphur	Windfall, Alta.	16	1,875
16. Steelman Gas	Steelman, Sask.	1	12
17. Shell Canada[1]	Waterton, Alta.	18-25	2,975
18. Amerada Hess Corp.	Olds, Alta.	11	600
19. Mobil Oil Canada	Wimborne, Alta	14	244
20. Hudson's Bay Oil and Gas	Edson, Alta.	3	304
21. Canadian Superior Oil	Harmattan-Elkton, Alta.	53	805
22. Hudson's Bay Oil and Gas	Lonepine Creek, Alta	8-17	201
23. Canadian Delhi Oil[1]	Minnehik-Buck Lake, Alta		32
24. Amoco Canada Petroleum	East Crossfield, Alta.	34	1,480
25. Amoco Canada Petroleum	Bigstone Creek, Alta.	19	320
26. Hudson's Bay Oil and Gas	Caroline, Alta.		18
27. Hudson's Bay Oil and Gas	Kaybob South, Alta.	2-17	1,044
28. Aquitaine Co. of Canada	Rainbow Lake, Alta.		70
29. Hudson's Bay Oil and Gas	Hespero, Alta.		11
30. Hudson's Bay Oil and Gas	Sturgeon Lake South, Alta		50
31. Hudson's Bay Oil and Gas[1]	Brazeau River, Alta		59
32. Shell Canada	Simonette River, Alta.		90
33. Atlantic Richfield	Gold Creek, Alta.		100
34. Gulf Oil Canada[2]	Strachan, Alta.		830
35. Hudson's Bay Oil and Gas	Kaybob South, Alta.		1,066
36. Imperial Oil[2]	Quirk Creek, Alta.		286
37. Shell Canada	Burnt Timber Creek, Alta.		190
38. Canadian Superior Oil[2]	Lonepine Creek, Alta.		145
39. Chevron Standard[2]	Kaybob South, Alta.		2,850
40. Aquitaine Co. of Canada[2]	Ram River, Alta.		1,900
41. Tenneco Oil & Minerals[2]	Brazeau River, Alta.		40
42. Canadian Ind. Gas	Kessler, Alta.		7
Total daily rated capacity December 31, 1971			22,246

[1]Plants increased capacity in 1971. [2]New plants 1971.



removed from gas prior to marketing. Elemental sulphur which is produced in the process is therefore an involuntary byproduct of the natural gas operation.

Sulphur recovery in Canada from Athabasca oil sands and crude oil is comparatively minor at present and from coal is virtually nil. However, with ever-increasing energy requirements and more and more stringent air pollution regulations coming into force, these vast sources of sulphur will, in the foreseeable future, contribute substantially to the world supply.

Sour natural gas. Many of the natural gas fields in western Canada contain hydrogen sulphide. Although the H_2S content of these sour gas fields ranges as high as 87 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 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:

$$2H_2S + 3O_2 \rightarrow 2H_2O + 2SO_2$$
$$2H_2S + SO_2 \rightarrow 2H_2O + 3S$$

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. The tail gases are incinerated and released to the atmosphere and liquid sulphur is fed into an underground storage pit for pumping to outside storage blocks where it cools and solidifies.

Canada's first sour natural gas sulphur recovery plant came on stream in Alberta in 1951, and sulphur output in 1952 amounted to 8,000 long tons. In 1971, 42 plants were operating including one in each of

Saskatchewan and British Columbia with a combined daily capacity* of 22,246 long tons. Production of elemental sulphur in Alberta as reported by the Alberta Energy Resources Conservation Board was 4.49 million long tons, an increase of 8 per cent over 1970. Production in British Columbia was 66,468 long tons and in Saskatchewan was 2,996 long tons in 1971 giving a total for the year of 4.54 million long tons of elemental sulphur derived from sour gas.

According to the Alberta Energy Resources Conservation Board Alberta's recoverable reserves of sulphur from sour gas fields amounted to an estimated 159.1 million long tons in 1970.

Alberta sulphur sales were 2,671,833 million long tons, a drop of 13 per cent from the record volume marketed in 1970, in spite of continued deterioration in world prices. The value of sales declined from $28,265,495 in 1970 to $19,283,770 in 1971. Alberta inventories stood at 5.32 million long tons at year end. Elemental sulphur sales from British Columbia and Saskatchewan were 52,832 long tons and 1,009 long tons and inventories were 79,264 long tons and 6,453 long tons, respectively, in 1971.

Table 3. Proposed new plants and expansion for 1972

Operating Company	Location	Proposed Daily Rated Capacity
		(long tons)
Aquitaine Co. of Canada	Ram River, Alta. (Stage 2)	4,000
Imperial Oil	Joffre, Alta.	27
Westcoast Transmission	Fort Nelson, B.C.	250
Aquitaine Co. of Canada[1]	Rainbow Lake, Alta	140
Shell Canada[1]	Simonette, Alta.	225
Chevron Standard[1]	Nevis, Alta.	258
Home Oil[2]	Carstairs, Alta.	60
Sun Oil	Black Diamond, Alta.	13
Anticipated daily rated capacity end of 1972		24,913

[1] Expansions to existing plants.
[2] Replacement of old plant.

In 1971, six new gas plants and expansions to three others raised daily capacity by 7,397 long tons to 22,246 long tons, a record annual increment of 50 per cent over the previous year's total. The new plants are: Canadian Superior Oil Ltd., Lone Pine Creek (145),* Chevron Standard Limited, Kaybob South (2,850), Aquitaine Company of Canada Ltd., Ram River stage one (1,900), Imperial Oil Limited, Quirk Creek (286), Gulf Oil Canada Limited, Strachan (830) and Tenneco Oil & Minerals, Ltd, Brazeau River (40). Expansions to existing plants completed in 1971 are: Shell Canada Limited, Waterton (1,325), Canadian Delhi Oil Ltd., Minnehik-Buck Lake (14), and Hudson's Bay Oil and Gas Company Limited, Brazeau River (9). The upsurge in production capacity is due to continued growth in demand for Canadian natural gas, particularly in the United States.

Most of the new capacity came on stream late in 1971 resulting in only a moderate increase over 1970 production. The full impact of the new capacity will be felt in 1972 and output is expected to reach 6.5 million long tons in that year. Additional capacity scheduled to come on stream in 1972 includes four new plants and expansions to four others. Stage two of Aquitaine Company of Canada Ltd.'s Ram River project, scheduled to come on stream in October 1972, will account for most of the increment and, when completed, the combined stages will have a total capacity of 4,000 tons per day, the largest sour gas sulphur recovery unit in the world. Imperial Oil Limited's Joffre, Alberta (27), Westcoast Transmission Company Limited's Fort Nelson, British Columbia (250) and Sun Oil Company Limited's Black Diamond, Alberta (13) plants are slated for completion during 1972, as well as expansions to Aquitaine's Rainbow, Shell's Simonette, Chevron's Nevis and Home Oil's Carstairs plants, bringing total daily capacity by the end of 1972 to 24,913 long tons. Production in 1973, as a result of increased capacity during 1972, is expected to reach 7.3 million long tons. The last major sour gas reserves discovered are those of the Ricinus West field, the source for the Ram River plant. Because of a lag of four or five years between discovery and plant start-up, no major increments in sulphur capacity can be expected prior to 1976 at the earliest.

The offshore market, which accounts for 60 per cent of Canada's exports, remains extremely important. Sulphur destined for these markets is currently railed in bulk from Alberta to loading terminals at Vancouver, some 650 miles from Alberta processing plants. Transportation, therefore, constitutes a major economic factor in the competitive marketing of Canadian elemental sulphur. In mid-1970, unit-train movement of sulphur was inaugurated resulting in substantial savings in transportation costs. However, even with these savings, loading, transportation and terminal handling costs still exceed the average net back to the Alberta plant per ton of sulphur marketed offshore. For example, the average value of marketed sulphur in Alberta for the year

*Daily capacity, which is based upon the design maximum raw gas throughput, is never sustained throughout the year as gas sales are subject to seasonal fluctuations.

*Rated daily capacity long tons.

1971 was $7.22 a long ton. With 1970 unit-train rates ($6.40 a long ton Alberta staging plant to Vancouver) transportation, loading and terminal handling costs approached $9 a ton.

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 Alberta Oil and Gas Conservation Board estimates that oil reserves in place exceed 600 billion barrels. The bitumen averages 4.5 per cent by weight sulphur, thereby constituting an extremely large reserve of sulphur. The Canadian Petroleum Association estimates reserves that could be recovered by the existing oil sand extraction plant at 40.8 million long tons of sulphur.

In late 1967, Great Canadian Oil Sands Limited (GCOS) completed the first commercial oil-sand oil extraction plant at a cost of $240 million. The ancillary sulphur recovery plant is designed to produce 300 long tons of sulphur daily. Operating problems which the plant has experienced since start-up have been alleviated following modifications and installation of new equipment. Sulphur production has consequently increased from 47,000 long tons in 1970 to 60,000 long tons in 1971. In December 1971, Syncrude Canada Ltd. obtained approval from the Alberta Energy Resources Conservation Board to increase the previously proposed production rate of 80,000 b/d to 130,500 b/d synthetic crude oil and products. This project is slated to come on stream after 1975 to meet anticipated oil requirements towards the end of the 1970's and will result in the annual recovery of about 185,000 long 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 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 and Quebec. Output from these refineries is not included in Canadian sulphur production statistics but is estimated to be 80,000 long tons in 1971. Sulphur, recovered from domestic crudes at oil refineries near Toronto. Sarnia, Winnipeg, Edmonton and Vancouver, amounted to an estimated 100,000 tons in 1971. More rigid regulations designed to combat air pollution will undoubtedly result in increased sulphur recovery from this source in the years ahead. Refinery installations and expansions proposed to 1975 will increase capacity by about 15 per cent and total sulphur produced from Canadian oil refineries will reach 230,000 long tons per year.

Coal. 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.

A research agreement between the United States Department of the Interior and the American Gas Association was entered into in July 1971 in which $300 million will be spent over an eight-year period with the aim of developing an optimum process for the commercial production of high-quality, pollution-free gas from coal by 1980. This measure is being taken in the hope of meeting a demand which is anticipated to outstrip growth of natural gas reserves in the United States. Large quantities of sulphur could ultimately be produced in coal gasification plants. Although coal in western Canada is low in sulphur (less than 0.5%), 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 1920's 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 1971 metallic sulphides provided 830,000 short tons of contained sulphur and accounted for only 14 per cent of Canada's total sulphur production.

Smelter gases. Effluent gas from smelting of sulphide ores contain from 1 to 12 per cent sulphur dioxide (SO_2). Recovery of the 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. Occasisionally, the SO_2 is compressed to liquid sulphur dioxide and in some cases is used for the manufacture of oleum (fuming sulphuric acid, $H_2S_2O_7$).

For this review, sulphur in smelter gases includes sulphur values recovered from metallurgical SO_2 gases and converted directly to H_2SO_4, liquid SO_2 and oleum. These metallurgical works include base-metal and iron ore recovery plants located in New Brunswick, Quebec, Ontario and British Columbia.

Table 4. Canada, principal sulphur operations based on metallic sulphides, 1971

Operating Company	Plant Location	Raw Material	Annual Capacity (short tons) 100% H_2SO_4	Approx. S equiv.
Smelter Gases				
Belledune Acid	Belledune, N.B.	SO_2 lead-zinc	250,000	80,000
Alcan	Arvida, Que.	SO_2 zinc conc.	50,000	17,000
Allied Chemical	Valleyfield, Que.	SO_2 zinc conc.	160,000	53,000
Allied Chemical	Falconbridge, Ont.	SO_2 pyrrhotite	–	135,000[1]
Can. Electrolytic Zinc	Valleyfield, Que.	SO_2 zinc conc.	135,000	45,000
Sherbrooke Metallurgical	Port Maitland, Ont.	SO_2 zinc conc.	90,000	30,000
Canadian Industries	Copper Cliff, Ont.	SO_2 pyrrhotite	750,000	250,000[2]
Cominco	Kimberley, B.C.	SO_2 pyrrhotite	360,000	120,000
Cominco	Trail, B.C.	SO_2 lead-zinc	490,000	160,000[2]
			Product	
Pyrite and Pyrrhotite				
Noranda Mines	Noranda, Que.	Sulphide ore	Pyrite concentrate	
Normetal Mines	Normetal, Que.	Sulphide ore	Pyrite concentrate	
Quemont Mines	Noranda, Que.	Sulphide ore	Pyrite concentrate	
Anaconda	Britannia, B.C.	Sulphide ore	Pyrite concentrate	

[1]Sulphur in elemental form. [2]Includes sulphur content in liquid SO_2 production.
– Nil.

Production in 1971 was 676,000 short tons of contained sulphur, a drop of 5 per cent from 1970.

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 daily capacity of 2,255 tons of H_2SO_4 based on SO_2 gas from The International Nickel Company of Canada, Limited's iron ore recovery plant. In addition, CIL operates 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 is building a new sulphuric acid depot and storage centre at Niagara Falls, Ontario, which is scheduled for completion by mid-1972. The $1.5-million facility consists of a 60,000-ton storage tank with equipment for unloading unit trains and loading tank cars and trucks. Acid from Copper Cliff will be shipped directly to the new facility via 56-car unit-trains.

Sulphuric acid is also produced from smelter gases by Belledune Acid Limited at Belledune, New Brunswick. This company, a subsidiary of Brunswick Mining and Smelting Corporation Limited, supplies acid to the adjacent plant of Belledune Fertilizer Limited, which is also a subsidiary of Brunswick.

Cominco Ltd. operates sulphuric acid plants at Kimberley and Trail, British Columbia, based on its pyrrhotite roaster and lead-zinc smelter, respectively. Combined capacity of these acid plants is in the order of 850,000 short tons of H_2SO_4 a year. Much of the acid produced is utilized by Cominco in the manufacture of fertilizers.

Aluminum Company of Canada, Limited, Allied Chemical Canada, Ltd., and Canadian Electrolytic Zinc Limited produce sulphuric acid from the roasting of zinc concentrates at Arvida and Valleyfield, Quebec. Sherbrooke Metallurgical Company Limited closed down its operations at Port Maitland, Ontario, in July 1971.

Allied Chemical's elemental sulphur recovery unit associated with the pyrrhotite roasting facility of Falconbridge Nickel Mines Limited, at Falconbridge, Ontario, was completed in 1970. Plant capacity is 135,000 short tons per year.

Texas Gulf Sulphur Company's new Timmins, Ontario zinc plant, which was scheduled to start up in April 1972, will produce about 230,000 tons of sulphuric acid annually. Gaspé Copper Mines, Limited, a subsidiary of Noranda Mines Limited is expanding its facilities at Murdochville, Quebec, at a cost of $22 million. Sulphuric acid production will be about 500,000 short tons. Half will be used to leach low-grade oxide ore at the mine, some will be shipped to the Belledune, New Brunswick fertilizer plant and the remainder to other markets. The new facility is expected to be ready in 1973. Cominco Ltd. and Bethlehem Copper Corporation Ltd. are examining the feasibility of a copper smelter possibly at Kimberley to treat concentrates from the Highland Valley in British Columbia. Such a facility would be capable of producing 500,000 short tons of H_2SO_4 per year.

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 used in this review is based upon this concept. For example, although most of the acid production at Copper Cliff, Ontario, and Kimberley, British Columbia, is dependent upon the roasting of iron sulphides, the sulphur production is reported as smelter gases. In other instances, however, the iron sulphide concentrates are sold and shipped for roasting elsewhere, so this production is reported as pyrite and pyrrhotite.

Three companies – Noranda Mines Limited, Normetal Mines Limited, and the Anaconda Company (Canada) Ltd. – are engaged from time to time in shipping pyrite and pyrrhotite concentrates to pyrite roasters, principally in northeastern United States. A fourth company, Quemont Mines Limited, closed down in 1971. Other companies are stockpiling pyrite concentrates pending development of future markets for this material. In 1971 Canada's pyrite and pyrrhotite shipments amounted to 318,000 short tons of concentrates (154,000 short tons contained sulphur) valued at $1,186,000. This tonnage is down from previous years because of low sulphur prices and probably marks the beginning of a failling trend in the future importance of this source of sulphur.

Canadian consumption and trade

Canadian consumption of sulphur as reported by consumers in all forms in 1971 amounted to an estimated 1.54 million short tons, of which elemental sulphur accounted for 55 per cent. Domestic consumption accounted for less than 40 per cent of producers shipments, clearly demonstrating that Canada is highly dependent upon export markets for sulphur sales. Except for minor tonnages of pyrite concentrates, all exports are in the elemental form from western Canada. Of a total of 3.90 million short tons of elemental sulphur marketed, only .85 million or 22 per cent was consumed domestically.

Canada's position as the largest supplier to world markets may have been relinquished to Poland in 1971. Poland's rapid expansion in export sulphur trade over the last few years was sustained in 1971 while Canada's sales to world markets dropped appreciably. Exports of Canadian elemental sulphur in 1971 were 2,647,893 short tons, a decline of 12 per cent from the record volume in 1970. Value of exports was conjointly diminished by the further deterioration of prices during the year to $27 million from $43 million in 1970 and $63 million in 1969.

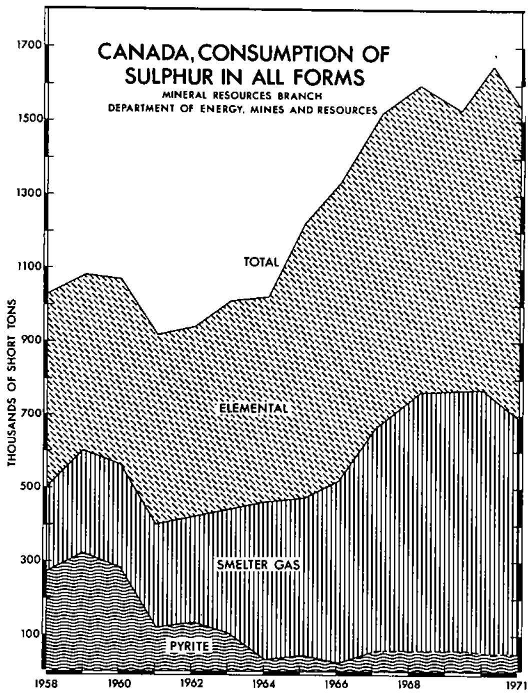
Despite a reduction in elemental sulphur shipments to the United States of 15 per cent from 1970's volume, this remains Canada's most important market

Table 5. Canada, sulphur production and trade, 1962-71

(short tons)

	Production[1]				Imports	Exports	
	In Pyrites[3]	In Smelter Gases	Elemental Sulphur	Total	Elemental Sulphur	Pyrite[2]	Elemental Sulphur
						($)	
1962	257,084	292,728	695,098	1,244,910	195,089	890,055	400,026
1963	235,410	353,243	1,249,887	1,838,540	150,637	937,883	820,929
1964	173,182	443,448	1,788,165	2,404,795	149,567	878,545	1,294,587
1965	186,960	444,758	2,068,394	2,700,112	162,201	978,828	1,497,947
1966	162,300	500,338	2,041,528	2,704,166	145,465	981,000	1,399,096
1967	182,377	592,035	2,499,205	3,273,617	124,781	1,067,000	1,773,671
1968	155,842	666,370	2,580,746	3,402,958	75,815	1,056,000	2,111,135
1969	171,212	676,189	2,973,506	3,820,907	45,508	1,105,000	2,246,281
1970	175,523	705,876	3,548,310	4,429,709	53,455	1,226,000	2,988,432
1971[p]	154,000[e]	676,000	3,065,000	3,895,000	30,782	1,074,000	2,647,893

Source: Statistics Canada.
[1]See footnotes for Table 1. [2]Dollar value of pyrite exports, quantities not available. [3]Excludes pyrite used to make byproduct iron sinter beginning in 1961.
[p]Preliminary; [e]Estimated.



accounting for almost 40 per cent of total exports. Involuntary byproduct sulphur from western Canada, because of its highly competitive nature, has penetrated a large portion of the United States domestic market. Since 1969, eight high-production-cost Frasch sulphur mines in the United States have been forced to close down because of the rapid deterioration in sulphur prices.

Recognizing the impact of Canadian imports on the domestic market, Senator Russell Long (Louisiana) introduced Bill S.4075 into the United States Congress in July 1970. This Bill, which to date has made little progress through Congress, seeks to restrict sulphur imports into the United States to the average quantity imported on a country-by-country basis during the calendar years 1965-1967. The terms of the Bill would require a decrease of about 25 per cent in the current level of Canadian sulphur imports.

Freeport Sulphur Company and Duval Corporation, both major United States Frasch sulphur-producing companies presented statements during the latter part of 1970 to the U.S. Tariff Commission claiming that Canadian sulphur was entering the United States at prices below actual production costs and thereby indicating that Canadian producers were guilty of unfair competitive business practices. Both companies supported Senator Long's Bill.

Table 6. Canadian export markets 1971

Country or Area	Exports	Per Cent of Total
	(millions of tons)	
United States	1.01	38.1
Europe	.52	19.6
India	.17	6.4
Taiwan	.12	4.5
Australia	.25	9.5
New Zealand	.17	6.4
Korea	.14	5.3
Others	.27	10.2
Total	2.65	100.0

Table 7. Canada, sulphur consumption, 1962-71
(short tons)

	From Pyrites and Smelter Gases^{e}	Elemental Sulphur[1]	Total^{e}
1962	427,097	522,903	950,000
1963	451,550	558,450	1,010,000
1964	485,608	544,392	1,030,000
1965	490,777	739,223	1,230,000
1966	516,889	812,111	1,329,000^{r}
1967	661,050	843,373	1,504,423^{r}
1968	750,183	830,147	1,580,330^{r}
1969	762,139	770,846	1,532,985
1970	765,000	889,992	1,654,992
1971^{p}	691,000	850,000^{e}	1,541,000

Source: Statistics Canada.
[1] As reported by consumers.
^{e}Estimated by Mineral Resources Branch.
^{p}Preliminary; ^{r}Revised.

In December 1970 representatives of the Province of Alberta met in Mexico City with other major world sulphur producers including Mexico, France and Poland to review the long-term world sulphur supply-demand situation. From this and subsequent meetings, an informal agreement was reached on a stockpiling mechanism which would regulate world sulphur markets to alleviate rapidly deteriorating sulphur prices. To this end, inventory control guidelines to be implemented on January 1, 1972 were announced by the Alberta Government in July 1971, and in September 1971 Mexico instituted similar supply-control measures. Alberta abandoned the proposed scheme in November 1971.

Table 8. Canada, consumption of elemental sulphur by industry, 1969-70

	1969	1970
	(short tons)	
Chemicals	177,224	263,090
Pulp and Paper	417,107	441,771
Rubber products	3,902	3,958
Fertilizers	146,716	115,825
Foundry	3,657	3,951
Other Industries[1]	22,240	61,397
Total	770,846	889,992

Source: Statistics Canada. Breakdown by Mineral Resources Branch.
[1]Includes production of titanium pigments, pharmaceuticals and medicinals, starch, soaps and detergents, explosives, food processing, sugar refining and other minor uses.

Table 9. Canada, sulphuric acid production, trade and apparent consumption, 1962-71

(short tons – 100% acid)

	Production	Imports	Exports	Apparent Consumption
1962	1,696,000	7,162	34,960	1,668,202
1963	1,790,000	5,634	37,316	1,758,318
1964	1,941,000	4,209	67,409	1,877,800
1965	2,165,000	3,075	57,113	2,110,962
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^p	2,932,559	4,952	101,094	2,836,417

Source: Statistics Canada.
^{p}Preliminary.

Freeport and Duval, following up on their 1970 initiatives made further submissions in 1971 and early 1972 to the United States Bureau of Customs resulting in antidumping proceedings being promulgated against Mexico on February 5, 1972 and Canada on February 17, 1972. Clearly the free entry of Canadian sulphur into the United States at current price levels is now under considerable pressure.

Table 10. Canada, available data on consumption of sulphuric acid by industry, 1969

	(short tons– 100% acid)
Iron and steel mills	46,270
Other iron and steel	11,735
Electrical products	5,773
Leather tanneries	3,158
Pulp and paper mills	91,298
Processing of uranium ore	88,134
Manufacture of mixed fertilizers[1]	67,514
Manufacture of plastics and synthetic resins	26,889
Manufacture of soaps and cleaning compounds	18,951
Other chemical industries	9,676
Manufacture of industrial chemicals[2]	1,446,011
Petroleum refining	33,269
Mining[3]	50,000^e
Nonferrous smelting and refining	262,000
Miscellaneous[4]	45,250
Total accounted for	2,205,928

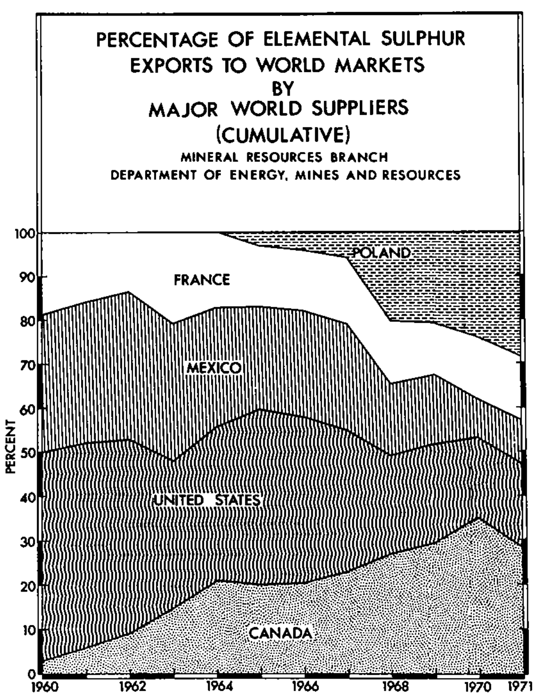
Source: Statistics Canada.
[1]Includes consumption for production of superphosphate in this industry. [2]Includes consumption of "own make" or captive acid by firms, classified to these industries. [3]Includes metal mines, nonmetal mines, mineral fuels and structural materials. [4]Includes synthetic 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.

World review

World sulphur production exceeded demand for the fourth consecutive year in 1971 augmenting already substantial inventories and depressing prices to record lows. This is attributable as in the last few years to a combination of slow growth in the major sulphur-consuming industries and increased world production. Canada suffered a substantial decrease in world sales in 1971 having been displaced largely by the continued rapid growth of Poland's western world exports. Export sales by other major producers including the United States and France have also increased and the United States has recaptured part of its own domestic market which was previously supplied by Canada. Marked reductions in sulphur prices have caused transportation costs to assume critical importance in Canada's position as a competitor. Unit sulphur train rates between Alberta and Vancouver are currently $6.40 per long ton, and handling and loading costs at the ocean terminal is around $2.50 per ton. Recently quoted figures for ocean freight from

Vancouver to India and Rotterdam are $11.75 and $5.10 per long ton making total transportation costs from Alberta to these destinations $20.65 and $14 per ton, respectively. Polish transportation costs to European markets are significantly lower in comparison and to India are about $10.50 per ton, a considerable advantage over Canada in spite of the higher costs of Frasch production. United States transportation costs to Europe are about $7 per ton lower than Canadian figures. The expansion by Frasch producers of liquid sulphur shipments and liquid storage facilities, which reduce both handling costs and consumer plant costs (a saving of as much as $2 per ton), provides a further advantage to Canada's competitors.

Consumption of sulphur in the western world amounted to an estimated 30.6 million metric tons, an increase of 4 per cent over 1970. Western world sulphur production, in all forms, was 30.5 million metric tons. Poland's production in 1971 reached an estimated 3.4 million metric tons – an increase of 18 per cent over 1970 and exports are estimated to have exceeded 2.3 million metric tons, of which about 1.75 million metric tons were delivered to western world markets. Polish production is obtained from the new Machow open pit and, by the Frasch method, from underground mines.



SOURCE: BRITISH SULPHUR CORPORATION TO 1970
MINERAL RESOURCES BRANCH ESTIMATE FOR 1971

Table 11. World production of sulphur in all forms, 1970

	Elemental	Other[1]	Total
	(thousands of metric tons)		
United States	8,662	1,575	10,237
U.S.S.R.	2,025	4,839	6,864
Canada	4,401	803	5,204
Poland	2,670	200	2,870
Japan	343	2,472	2,815
France	1,740	232	1,972
Spain	6	1,439	1,445
Mexico	1,381	34	1,415
Italy	56	813	869
West Germany	193	623	816
Finland	115	384	499
Britain	32	424	456
Norway	2	381	383
East Germany	109	260	369
Others	1,156	4,441	5,597
Total	22,891	18,920	41,811

Source: British Sulphur Corporation, November/December 1971.
[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.

The world's largest producer of sulphur in all forms is the United States, with the majority of production derived from Frasch mines located in the Gulf Coast area. These deposits, when first developed in the early 1900's, 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 1969, for the first time in many years, Frasch sulphur production declined, dropping from 7.5 million long tons in 1968 to 7.1 million long tons. The decline in output continued through 1970 and in 1971 production had dropped to 7.03 million long tons. Recovered elemental sulphur increased from 1.46 million long tons in 1970 to 1.56 million long tons in 1971. Export of elemental sulphur increased 7 per cent over 1970 to 1.53 million long tons. Due to depressed prices, eight Frasch mines have been closed since 1969. Reduced capacity has been largely offset by Duval's new Culberson County, Texas mine having a capacity of about 1.5 million long tons per year.

In Mexico, production of elemental sulphur increased from 1.4 million long tons in 1970 to an estimated 1.5 million long tons in 1971.

Production of elemental sulphur from sour natural gas from the Lacq field in France reached 1.82 million long tons, an increase of 5 per cent from that of 1970.

A growing number of new sources are beginning to make their impact on the sulphur market. Frasch sulphur operations in Iraq were slated to begin toward the end of 1971 and production rates are expected to reach 1 million long tpy by the end of 1972. Sulphur recovery from natural gas in the Middle East has already begun and will expand over the next few years. Native sulphur deposits have been discovered in Angola and are likely to be developed in the near future. Pollution abatement sulphur sources are developing rapidly in all industrial nations and these will claim an ever-increasing share of the world market.

The continued deterioration of the situation into 1971 fomented national and international concern and action at government levels, giving rise to a new dimension in the sulphur scene. In the face of dwindling royalties from sulphur shipments, the Alberta Government initiated discussions leading to an informal agreement with Poland, France and Mexico on regulation of the sulphur market. Alberta subsequently withdrew from the arrangement. Recognizing the severity and long-term nature of the problem and cognizant of its role in requiring recovery of by-product sulphur to meet environmental quality and resource conservation commitments, the Canadian Government called two international meetings of major producer and consumer nations in 1971 and plans for future meetings have been made for the purpose of exploring ways of dealing with the oversupply problem. In addition, technical and economic feasibility studies were begun in 1971, directed by the National Research Council, to examine possible new uses for sulphur. Preliminary investigation of numerous large-tonnage potential uses including an asphalt-sand-sulphur mixture for road and airstrip paving, sulphur cement and other construction materials, pipeline insulation, etc., were examined. The Canadian initiative was followed by a similar project undertaken by the United States Bureau of Mines. Sulphur utilization was also added to the agenda of the International Review Group convened by Canada.

Outlook

Involuntary Canadian elemental sulphur, recovered from sour natural gas in western Canada, is one of the world's largest sources of abundant low-cost material and has, within the past decade, substantially altered the pattern of international sulphur supply. In 1960 Canada accounted for only 3.4 per cent of the world export market. In 1968, with a market share of 27.4 per cent, Canada became the world's largest exporter.

In 1971 Canada's export sales dropped 12 per cent from the record high in 1970 and her market share decreased correspondingly from 35 per cent to 27 per cent, approximately equal to or possibly lower than Poland's share.

In 1971, production of gas-associated sulphur was 4.5 million long tons an increase of less than 0.3 million long tons from 1970 because of late start-ups of new and expanded facilities. The full impact of these and additional projects to be completed will raise production in 1972 to 6.5 million long tons. By 1975 production is expected to reach 7.5 million long tons and by 1980, almost 10 million long tons. These figures are somewhat lower than earlier estimates because of the lack of recent discoveries in sour gas areas and the growing reluctance of companies to invest exploration funds in these areas at current sulphur and gas prices.

The world oversupply problem will likely continue throughout the decade as output from a multitude of sources will continue to increase far beyond market demand. Sulphur recovered from pollution abatement sources is likely to make serious inroads into markets now served by existing sources. Barring significant new uses for sulphur, world consumption is forecast to increase at about 4 per cent a year resulting in western world demand of some 36 million long tons in 1975 and 46 million long tons by 1980. International trade patterns will continue to change as many nations now net importers of sulphur will become net exporters.

Development of new uses remains the only long-term solution to the oversupply problem and the acceleration of research and development on this unique and versatile element will hopefully soon begin to bear fruit.

Prices

Reflecting the world oversupply situation and the extremely competitive nature of export markets, prices reached all-time lows during 1971. The pattern by month was a fluctuating one and an average of $7.22 per long ton fob Alberta plant for the year was obtained, indicating a deceleration of the decline and a possible bottoming out of prices. A firming trend in prices has been forecast by several observers on the strength of possible international developments. In the face of the large oversupply, however, price increases, if any, should be modest.

Canadian sulphur prices in 1971, quoted in Canadian Chemical Processing

Sulphur, elemental, fob works, contract, carload, per long ton	
	($)
January	11 – 12
March	6 – 10
May	7.50 – 9
December	7.50 – 9
Sulphuric acid, fob plants, East, 66° Be, tanks, per short ton	
December	31

United States prices in U.S. currency, quoted in Engineering and Mining Journal, December 1971

	($)
Sulphur, elemental	
U.S. producers, term contracts,	
fob vessel at Gulf ports,	($)
La. and Tex., per long ton	
Bright	40
Dark	39
	($)
Export prices, fob Gulf ports	
Bright	26
Dark	25
Mexican export, fob vessel per long ton	
Bright	26
Dark	25

Tariffs

Canada

Item No.		British Prefer-ential	Most Favoured Nation	General
92503-1	Sulphur of all kinds, other than sublimed sulphur, precipitated sulphur and colloidal sulphur	free	free	free
92802-1	Sulphur, sublimed or precipitated; colloidal sulphur	free	free	free
92807-1	Sulphur dioxide	free	free	free
92808-1	Sulphuric acid; oleum	10%	15%	25%
92813-4	Sulphur trioxide	free	free	free

United States

Item No.			Item No.		(%)
418.90	Pyrites	free	422.94	Sulphur dioxide	
415.45	Sulphur, elemental	free		On and after Jan. 1, 1970	8.5
416.35	Sulphuric acid	free		On and after Jan. 1, 1971	7
				On and after Jan. 1, 1972	6

Source: The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa. Tariff Schedules of the United States, Annotated (1970), TC Publication 344.

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 to which talc is put depend on individual physical properties or combinations of these properties.

Talc is produced in various grades which are usually classified by end use, such as cosmetic grade, ceramic grade, pharmaceutical grade and paint grade. 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, an art which has survived among the Eskimos up to the present era. Present uses include metalworker's 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. In 1971 the value of talc and soapstone shipments increased to $717,000 from $588,589 in 1970. The value of pyrophyllite production decreased from $553,305 in 1970 to $393,000 in 1971.

Production and developments in Canada

Talc, soapstone. The earliest recorded talc production in Canada was in 1871-72 when 300 tons valued at $1,800 were shipped from a deposit in Bolton Township, southern Quebec by Slack and Whitney. In 1896 a deposit in Huntingdon Township, in the Madoc district in Ontario was opened up and over the next few years, numerous deposits in this area were discovered 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 three companies, two in Quebec and one in Ontario.

Baker Talc Limited produces talc and soapstone from an underground mine at 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 the past, Baker Talc has produced a relatively low-grade, low-cost product suitable for use primarily as a dry-wall joint filler, asphalt filler and dusting compound for asphalt roofing. Tests conducted in 1967-68, employing a Jones High Intensity Wet Magnetic Separator, were successful in upgrading talc products for use in the paint, cosmetic and paper

Table 1. Talc, soapstone and pyrophyllite production, trade and consumption, 1970-71

	1970		1971p	
	(short tons)	($)	(short tons)	($)
Production (shipments)				
Talc and soapstone				
Quebec[1]	. .	253,700	. .	312,000
Ontario[2]	. .	334,889	. .	405,000
Total	. .	588,589	. .	717,000
Pyrophyllite				
Newfoundland	. .	553,305	. .	393,000
Total production	72,055	1,141,894	67,000	1,110,000
Imports (talc)				
United States	32,427	1,782,000	33,428	1,821,000
Italy	558	44,000	323	22,000
Britain	–	–	1	. . .
France	60	4,000	–	–
People's Republic of China	23	1,000	–	–
Total	33,068	1,831,000	33,752	1,843,000
	1969		1970p	
Consumption[3] (ground talc, available data)				
Ceramic products	9,870		8,505	
Paints and wall joint sealers	6,965		7,156	
Roofing	7,462		6,593	
Paper and paper products	4,166		3,699	
Rubber	1,705		1,682	
Insecticides	718		682	
Toilet preparations	923		843	
Cleaning compounds	653		734	
Pharmaceutical preparations	300		227	
Linoleum and tile	115		646	
Other products[4]	5,216		4,665	
Total	38,093		35,432	

Source: Statistics Canada.
[1]Ground talc, soapstone blocks and crayons. [2]Ground talc. [3]Breakdown by Mineral Resources Branch. [4]Chemicals, foundries, gypsum products and other miscellaneous uses.
pPreliminary; – Nil; . . Not available; . . . Less than $1,000.

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. Throughout 1970 the new beneficiation circuit was tuned and modifications were made, including the addition of more flotation capacity and a thickener. Trial shipments of upgraded talc were made in 1970-71 for assessment in pulp and paper manufacture. The product proved satisfactory and regular shipments began in 1971. The suitability of the refined product as a filler in plastics and paints is under investigation at the present time.

The company estimates ore reserves to be adequate for 15 to 20 years of operation. Along with talc output, the company from time to time markets soapstone blocks as an artistic medium to schools and art shops.

Broughton Soapstone & Quarry Company, Limited quarries talc and soapstone from 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 metalworker's crayons and blocks for sculpturing.

Canada Talc Industries Limited produces talc from underground workings at Madoc, Ontario. The deposits at Madoc are extensive and were formed by the

Table 2. Production and trade, 1962-71

	Production[1]				
	Talc and Soapstone	Pyrophyllite[2]	Total[3]	Imports Talc	Exports[e] Talc
	(st)	(st)	(st)	(st)	(st)
1962	23,367	22,794	46,161	24,148	2,200
1963	22,467	31,783	54,250	27,539	2,300
1964	25,316	32,816	58,132	31,598	2,700
1965	22,703	30,134	52,837	27,858	3,500
1966	29,596	40,548	70,144	24,918	6,000
1967	..	..	60,665	26,482	9,000
1968	..	..	80,589	28,244	10,000
1969	..	..	75,850	34,910	10,000
1970	..	..	72,055	33,068	8,000
1971[p]	..	..	67,000	33,752	9,000

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; [e]Estimated by Mineral Resources Branch.

alteration of dolomitic marble. Impurities in the deposit consist of tremolite and dolomite which limit the use of some ground products. A high-quality product suitable as a filler material in the paint industry is produced.

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. A few occurrences of soapstone in the Northwest Territories from which Eskimos obtained material for carving are known. 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 trucking 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.

Table 3. World production of talc, soapstone and pyrophyllite, 1969-71

	1969	1970[p]	1971[e]
	(st)	(st)	(st)
Japan	1,996,045	2,066,230	2,000,000
United States	1,029,938	1,027,929	1,053,000
U.S.S.R.	419,000	419,000	..
France	271,168	256,838	250,000
South Korea	198,733	224,941	..
India	206,674	185,641	..
Italy	150,466	170,657	150,000
People's Republic of China[e]	165,000	165,000	..
Austria	104,277	110,406	110,000
North Korea	77,000	88,000	..
Australia	60,704	72,568	..
Norway	70,807	70,000	70,000
Canada	75,850	72,055	67,000
Other countries	311,645	373,380	1,533,000
Total	5,137,307	5,302,645	5,233,000

Source: U.S. Bureau of Mines, *Minerals Yearbook*, Preprint 1970; U.S. Bureau of Mines Commodity Data Summaries, January 1972; Statistics Canada.
[p]Preliminary; [e]Estimate; .. Not available.

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.

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 in the Kyuquot Sound area, 200 miles northwest of Victoria, British Columbia. 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. It is anticipated that imported high-quality talc will soon be displaced to some extent in other industries by this domestic product. Imports in 1971 amounted to 33,752 tons valued at $1,843,000. Of this, 33,428 tons were imported from the United States and the remainder from Italy and Britain. Average value of imports in 1971 was $55 a ton while domestic production sells in the range of $10-25 a ton, depending upon quality.

Uses

Talc is used mostly in a fine-ground state although soapstone is used 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, 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 which increases the translucence and toughness of the finished product and aids in promoting crack-free glazing. For use in ceramics, talc must be free of 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 and abrasive impurities.

Lower-grade talc is used as a dusting agent for asphalt roofing and gypsum board; as a filler in dry-wall sealing compounds; as a filler material in floor tiles; in asphalt pipeline enamels; in auto-body patching compounds; as a carrier for insecticides and 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 able 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 27, 1971

	($ per ton)		($ per ton)
Canadian		California	
Ground, bags, carlot, fob mines	20-35	Domestic, ordinary, off-colour,	
Bags, less than carlots	26.60	bags, carlot, fob works	34-39.50
Vermont		New York	
Domestic, ordinary, off-colour,		Domestic, fibrous, ground, bags	33
ground, bags, carlot, fob works	22.25	Bags, less than carlots, fob works	36-37

Tariffs

Canada

Item No.		British Preferential	Most Favoured Nation	General
		(%)	(%)	(%)
71100-3	Talc or soapstone	10	15	25
71100-8	Micronized talc	free	5	25
29655-1	Pyrophyllite	free	free	25
29645-1	Talc for use in manufacture of ceramic tile (expires February 28, 1974)	free	free	25
29646-1	Talc for use in manufacture of pottery (expires February 28, 1974)	free	free	25

United States

Talc, steatite and soapstone

Item No.		On and After Jan. 1, 1971	On and After Jan. 1, 1972
523.31	Crude and not ground	0.02¢ per lb	
523.33	Ground, washed, powdered, or pulverized	7%	6%
523.35	Cut or sawed, or in blanks, crayons, cubes, disks, or other forms	0.2¢ per lb	0.2¢ per lb
523.37	All other, not provided for	14%	12%

Sources: The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa. Tariff Schedules of the United States, Annotated (1972), TC Publication 352.

Tin

G.S. BARRY

Canada is an important consumer but small producer of tin. The only producer is Cominco Ltd., which recovers cassiterite (SnO_2) as a byproduct from milling lead-zinc ores at Kimberley, British Columbia. The concentrate is exported to Mexico for smelting. In addition, Cominco obtains a lead-tin alloy from the treatment of lead bullion dross in the indium circuit of the Trail smelter, British Columbia. The company also produces, from purchased commercial-grade metal, small quantities of Tadanac brand high-purity tin (99.999 per cent) and special research-grade (99.9999 per cent).

Canadian production in 1971 of tin in tin concentrates and lead-tin alloys was 133 tons* valued at $512,000.

Canadian industrial requirements of tin are met by imports that in 1971 totalled 5,103 tons valued at $18,375,000. In addition, Canada imports tinplate and exports tin metal scrap and tinplate scrap mainly to the United States. Fifty-six per cent of Canadian metal imports came from Malaysia mainly as high-quality Straits brand.

Brunswick Tin Mines Limited, a subsidiary of Sullivan Mining Group Ltd., continued exploration of its Mount Pleasant property, near St. Stephen, New Brunswick. Drilling established two types of mineralization: tungsten-molybdenum-bismuth and copper-zinc-tin. The company reports 26.9 million tons of material of the first type which also contains 0.04 per cent tin and about 1 million tons of copper-zinc ore that contain 0.35 per cent tin. Metallurgical testing, with reportedly encouraging results, continued throughout 1971 and will be extended into 1972.

*Metric tons of 2,205 pounds are used throughout the 1971 review in contrast to long tons of 2,240 pounds used in reviews of preceding years.

Fine-grained cassiterite which cannot be recovered at present, is a mineralogical component of sulphide ores of some Canadian mines. It is present in small quantities in the zinc-lead orebodies of Brunswick Mining and Smelting Corporation Limited, New Brunswick and in the South Bay mine, Ontario, of Selco Mining Corporation Limited. During 1971 Ecstall Mining Limited, a subsidiary of Texas Gulf Sulphur Company, continued research on recovery of tin from the mill tailings of its zinc-copper-lead-silver ores at Timmins, Ontario. The company announced in 1972 that tin could be profitably recovered and that the initial rate would be 1,400 tons of 54 per cent tin concentrates per year. The date of start of production has not been announced.

The principal use of tin in Canada, accounting for just over 50 per cent of the total consumption, is in the production of tinplate. There are two producers: Dominion Foundries and Steel, Limited, and The Steel Company of Canada, Limited, both at Hamilton, Ontario. Canadian output of tinplate is all electrolytic, hot-dip production having ceased in 1966. It is estimated that approximately 2,500 tons of tin were consumed in 1971 for a production of about 470,000 tons of tinplate, the same as last year. The steel companies at Hamilton each had two electrolytic tinplate lines at the beginning of 1971. The Steel Company of Canada, Limited brought into operation its third line in November 1971. The new line has a capacity of 175,000 tons of tinplate a year and speeds of up to 1,500 feet per minute. With addition of ancillary equipment it can be converted to produce steel with other types of coatings, notably chrome-coated steel. Dominion Foundries and Steel, Limited will bring into operation a new dual-purpose electrolytic tinning line in March 1972.

Table 1. Canada, tin production, imports and consumption, 1970-71

	1970		1971^p	
	(metric tons)	($)	(metric tons)	($)
Production				
Tin content of tin concentrates and lead-tin alloy	120	421,946	133	512,000
Imports				
Blocks, pigs, bars				
Malaysia	3,802	14,785,000	3,183	11,400,000
United States	928	3,817,000	779	2,853,000
Nigeria	239	956,000	513	1,808,000
Thailand	–	–	385	1,400,000
Netherlands	76	324,000	97	398,000
Other Countries	66	266,000	146	516,000
Total	5,111	20,148,000	5,103	18,375,000
Tinplate				
United States	3,356	780,000	2,242	529,000
Britain	291	110,000	177	53,000
Other Countries	–	–	2	2,000
Total	3,647	890,000	2,421	584,000
Tin, fabricated materials, not elsewhere specified				
United States	37	143,000	25	110,000
Exports				
Tin in ores and concentrates and scrap				
Mexico	184	409,000	137	275,000
United States	78	29,000	45	98,000
Britain	–	–	34	87,000
Other Countries	5	11,000	–	–
Total	267	449,000	216	460,000
Tinplate scrap				
United States	21,956	666,000	21,473	592,000
Consumption				
Tinplate and tinning	2,594		2,549	
Solder	1,399		1,047	
Babbitt	182		154	
Bronze	238		170	
Galvanizing	4		10	
Other uses (including collapsible containers, foil, etc.)	137		126	
Total	4,554		4,056	

Source: Statistics Canada.
^{p}Preliminary; – Nil; . . Not available.

World developments

Tin is the only metal for which there is formal co-operation between producer and consumer interests and among governments to modify problems of price and demand. 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 postwar 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 tin industry is characterized by a low consumption growth rate and a widely fluctuating price for the metal.

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 Agreement came in force, respectively, on July 1, 1966 and on July 1, 1971. 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 40 out of the total of 1,000 votes allocated to consumers. The 20 consumer members in 1971 accounted for 59 per cent of total consumption. The United States is the main nonmember country among western consuming countries (53,854 tons). The total does not include most communist countries' consumption as the data is not available.

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 93 per cent of the noncommunist production of tin in concentrate.

For the Third Agreement producer members contributed cash to establish a buffer stock. The operation of the stock is vested in a manager appointed by the Tin 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 judgment to buy or sell tin metal, but not concentrates, on major markets to modify price fluctuations. Council may impose export controls to curtail metal supply if tin in the buffer stock and other conditions appear to warrant such action.

Table 2. Canada, tin production, exports, imports and consumption, 1961-71

	Production[1]	Exports[2]	Imports[3]	Consumption[3]
	(metric tons)			
1961	508	487	3,582	4,016
1962	296	292	2,310	4,579
1963	421	813	4,260	5,021
1964	160	334	4,927	4,899
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	308	5,024	4,349
1970	120	267	5,111	4,554
1971[p]	133	216	5,104	4,056

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. [3]Tin metal.
[p]Preliminary.

The Fourth Agreement, embodying the objectives and control mechanisms of the Third Agreement, came into force on July 1, 1971 with the following changes in membership: Australia became a producer member, having been a consumer member, and West Germany and the U.S.S.R. joined as new consumer members. The principal change is that the Buffer Stock Manager under the new agreement has the authority to both buy and sell in the upper and lower price sectors, which is expected to make buffer stock operations more flexible. Another change, not part of the terms of the Agreement, is that the International Monetary Fund will permit countries to finance their buffer stock contributions by the use of International Monetary Fund drawing rights. This permission was granted in recognition of the Agreements' importance as an intergovernmental stabilizing force in the commodity market. In total, out of contributions to the buffer stock of 20,000 tons equivalent (£27,000,000) the producing contributors can draw no less then £23,600,000 on the IMF facility.

The accompanying graph shows tin price fluctuations from 1951 to 1970 in relation to price ranges considered desirable by Council at various periods. Prices from 1951 to 1969 are shown in pounds sterling per long ton as quoted on the London Metal Exchange. Beginning on January 2, 1970, prices were quoted on the London Metal Exchange in pounds sterling per metric ton.

Throughout 1964 and 1965 prices exceeded the established ranges and problems were mainly those of increasing the supply. The shortfall between production and demand was met in various ways, including decreases in consumer stocks, sales from governmental stockpiles and improved utilization of tin by consumers. The prolonged stimulus of price gradually had the desired effect of increasing mine production.

Production of tin in concentrates from 1960 to 1968 rose significantly and during 1968 exceeded consumption. To correct the imbalance, the Tin Council from September 1968 to the end of 1969 maintained an export control program. Tin prices rose from a level of £1,370 per ton at the beginning of 1969 to £1,620 per ton at the end of that year.

During 1970 production rose, the Tin Council's buffer stock, private stocks and United States Government stocks were on balance reduced, while consumption of tin declined in the major consuming countries. Tin prices thus declined as increased supplies became available, and at December 31 were £1,438 per ton, compared with £1,620 at the start of 1970. Though price movement was relatively large, prices were in the neutral 'no action' and upper 'may sell' zones for most of the year. Production and consumption of tin were nearly in balance.

The Tin Council decided not to extend the authority of the Buffer Stock Manager to operate within the 'no action' middle sector after March 31, 1970; that is, the market mechanism after that date

Table 3. Estimated world[1] production of tin-in-concentrates, 1961, 1970-71

	1961	1970	1971
	(metric tons)		
Malaysia	56,028	73,794	75,445
Bolivia	20,664	30,100	30,270
Thailand	13,270	21,779	22,066
Indonesia	18,574	19,092	19,767
Australia	2,381	8,876	9,433
Nigeria	7,779	7,959	7,326
Zaire	6,570	6,458	6,500
Total including countries not listed	136,999	185,800	186,500

Source: International Tin Council, Statistical Bulletin.
[1]Excludes countries with centrally planned economies, except Czechoslovakia, Poland and Hungary; it should be noted that China (People's Republic) and USSR are large tin producers.

was allowed to operate freely in that sector. On October 21 the Council agreed to raise the floor price per metric ton in the Tin Agreement from £1,260 to £1,350 and the ceiling price from £1,605 to £1,650. The last previous adjustment, except for that made in November 1967 for the devaluation of the pound sterling and in January 1970 for the conversion from long to metric tons, had been made on July 1, 1966.

Under the Fourth Agreement effective July 1, 1971 the Buffer Stock Manager may buy or sell in the lower range but must be a net buyer for each financial quarter; similarly the Manager may buy or sell in the upper range but must be a net seller. The Council decided that the middle range (£1,460-1,540) will remain a 'no action' zone.

Price maintenance by buffer stock action resulted in the accumulation of 35 tons in 1966, rising to 4,755 tons by the end of 1967 and 11,290 tons at the end of 1968. The Council reduced its stocks during the period of export controls in 1969 to 4,590 tons at the end of the year and made further reductions in 1970 to 1,213 tons. Stocks held by the Buffer Manager were increased significantly during 1971, a year of slow economic growth and resultant weak demand for tin, to 6,637 tons as of December 31. Accumulation by the Buffer Stock Manager was particularly high in the fourth quarter, when the Manager apparently successfully exerted his influence to keep the price from falling below the £1,400 level. The Council did not impose export controls in 1971, an appropriate course of action considering the increase in demand evident in the first quarter of 1972.

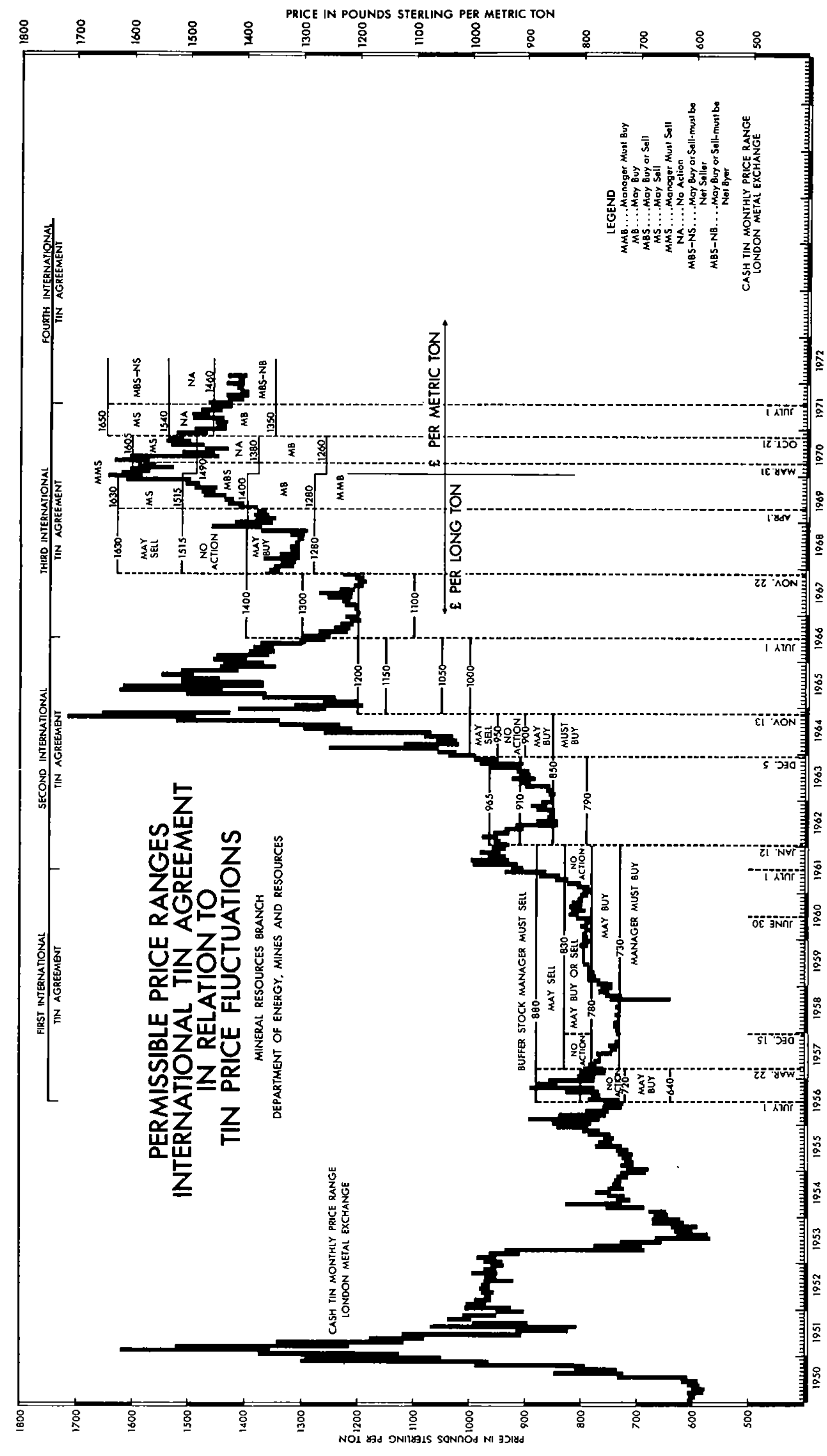
The United States stockpile originally held 348,310 long tons in 1962, before disposals began. The stockpile objective was raised on March 27, 1969 from 200,000 to 232,000 long tons, leaving 25,524 long tons authorized and available for disposal. Releases totalled 2,048 long tons in 1969, 3,038 long tons in 1970, and 1,736 long tons in 1971, all under the program of the United States Agency of International Development (AID). Releases from 1962 to the end of 1971 totalled 97,645 long tons, 80,000 of which were sold to commercial users and the remainder disposed of through AID and similar programs. At the end of 1971 the U.S. stockpile held 18,866 long tons of uncommitted excess stock authorized for disposal.

More than 75 per cent of world tin mine output is derived from dredging and hydraulicking operations. Lode mines account for most of the output of Bolivia, Australia, Britain and South Africa. Concentrating processes for tin, whether alluvial tin or lode, are chiefly based on relatively simple gravity separation methods that produce concentrates ranging from 50 to 75 per cent tin. Typical concentrates as delivered, for example, to Indonesia's Mentok smelter in 1971 graded 65 to 72 per cent tin. Lode mining tin companies have recently installed flotation plants to complement gravity separation and improve the recovery of other metals as well as some very fine tin. Some companies that have installed flotation plants are South Africa's Union Tin Mines (installation,

Table 4. Estimated world[1] production of primary tin metal, 1961, 1970-71

	1961	1970	1971
	(metric tons)		
Malaysia	80,384	90,312	87,095
Britain	25,943	22,035	23,153
Thailand	–	22,040	21,679
Netherlands	2,773	5,937	837
Federation of Nigeria	633	8,069	7,348
Belgium	6,098	4,257	3,940
Indonesia	1,829	5,190	9,218
United States	8,636	4,540	4,450
Australia	2,641	5,211	6,333
Spain	670	2,990	4,827
Brazil	1,593	3,100	3,424
Japan	1,669	1,375	1,283
Republic of Zaire	2.439	1,396	1,350
Total, including countries not listed	141,129	181,500	186,100

Source: International Tin Council, Statistical Bulletin.
[1]Excludes countries with centrally planned economies, except Czechoslovakia, Poland and Hungary.
– Nil.



PERMISSIBLE PRICE RANGES
INTERNATIONAL TIN AGREEMENT
IN RELATION TO
TIN PRICE FLUCTUATIONS
MINERAL RESOURCES BRANCH
DEPARTMENT OF ENERGY, MINES AND RESOURCES
PRICE IN POUNDS STERLING PER METRIC TON
PRICE IN POUNDS STERLING PER TON
FIRST INTERNATIONAL TIN AGREEMENT
SECOND INTERNATIONAL TIN AGREEMENT
THIRD INTERNATIONAL TIN AGREEMENT
FOURTH INTERNATIONAL TIN AGREEMENT
CASH TIN MONTHLY PRICE RANGE
LONDON METAL EXCHANGE
BUFFER STOCK MANAGER MUST SELL
MAY SELL
MAY BUY OR SELL
MAY BUY
MANAGER MUST BUY
NO ACTION
£ PER LONG TON
£ PER METRIC TON
LEGEND
MMB....Manager Must Buy
MB....May Buy
MBS....May Buy or Sell
MS....May Sell
MMS....Manager Must Sell
NA....No Action
MBS-NS....May Buy or Sell-must be Net Seller
MBS-NB....May Buy or Sell-must be Net Byer
CASH TIN MONTHLY PRICE RANGE
LONDON METAL EXCHANGE
1950
1951
1952
1953
1954
1955
1956
1957
1958
1959
1960
1961
1962
1963
1964
1965
1966
1967
1968
1969
1970
1971
1972

1971); Australia's Cleveland mine (1972) and Renison mine (1970); the Catavi mill in Bolivia (1970); and in Britain, the new Wheal Jane mine of Consolidated Gold Fields Limited (1971). South Africa's Rooiberg Minerals Development Company expects to complete new flotation facilities by January 1973.

The largest lode tin mines are Bolivian, from which concentrates were exported mainly to Britain with smaller amounts to the United States. In January 1971 the Empressa National de Fundiciones (National Foundry Company) of Bolivia commissioned the Vinto smelter. It has a planned initial capacity of 7,500 tons per annum of electrolytic tin and 800 tons of tin alloy, with the provision for two further stages, each of 7,500 tons. The Oruro smelter that refined minor tonnages of Bolivian tin in the past is now operating as a volatilization plant only. In addition the U.S.S.R. is helping to install four special volatilization plants. Each will treat 500,000 tons tailings a year, containing from 0.07 to 3.0 per cent fine tin. The concentrate, of approximately 50 per cent tin, will be sent to the Vinto smelter. The first plant is expected to be operational at Catavi in 1973; others will be at Huanani, Colquiri and Oruro.

The Indonesia State Tin Enterprise, P.N. Timah, announced that beginning in late 1971 construction will start on the expansion of its Peltim smelter from 13,000 to 27,000 tons capacity per annum. The Peltim smelter was commissioned in 1967; it operated at 40 per cent capacity in 1970 and at 70 per cent capacity in 1971.

N.V. Hollandse Metallurgische Industrie Billiton closed its Arnhem smelter on July 2, 1971. It was in operation since 1928, and in the past reached production levels close to its rated capacity of 30,000 tons per year.

The Gulf Chemical & Metallurgical Corporation, which operates the Texas City smelter, resumed the smelting of Bolivian concentrates in May 1970 after a suspension of activities since early 1969.

The Thaisarco smelter, Phuket Island, Thailand, changed controls in 1971. It will now be controlled 50 per cent by Union Carbide Corporation and 50 per cent by Billiton. In 1971 the smelter operated at approximately 75 per cent of its rated annual capacity of 28,000 tons.

Associated Tin Smelters Pty. of Alexandria, Australia, which operated in 1971 at an annual rated capacity of 4,500 tons of tin, is raising its capacity to 9,000 tons in 1972. Australian tin in concentrates production rose from 8,000 tons in 1969 to 9,433 tons in 1971 and prospects are good for further increases in mine output in 1972. Following the collapse of Mineral Securities of Australia, Cominco Ltd. purchased in late 1971 a controlling interest in Aberfoyle, Australia's leading tin mine.

Nigerian production at the Makeri Smelting Co. Ltd. plant at Jos continued to face problems of inadequate supply of concentrates because of production difficulties and strikes in 1971.

Britain's third and fourth tin mines were opened during 1971. Consolidated Gold Fields' Wheal Jane mine was officially opened on October 1. It will produce 1,400 tons of tin per year, operating a mill at 610 tons daily. Ore reserves are 5 million tons, grading 1.25 per cent tin. The Pendares mine (Camborne Mines Ltd.) began production in November. It will produce approximately 87,000 tons of ore per year. In 1971 Britain produced 1,816 tons of tin and consumed 16,418 tons.

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

Table 5. Estimated world[1] tin position, 1969-71

	1969	1970	1971
	(metric tons)		
Ore Supply			
Production of tin-in-concentrates	179,637	185,800	186,500
Stocks at year's end	23,979	20,100	13,600
Primary Metal Supply Smelter			
Production of tin metal	177,065	180,600	185,300
Net sales to centrally planned countries	6,198	4,593	4,913
Government stockpile sales	2,081	3,087	1,764
Buffer stock, sales + purchases –	6,808+	3,431+	5,405–
Commercial stocks at year's end	49,786	43,400	44,900
Primary metal consumption	184,413	179,899	186,000

Source: International Tin Council, Statistical Bulletin.
[1]Excludes countries with centrally planned economies except Czechoslovakia, Poland and Hungary.

industry. Available world data indicate that 76,000 tons of tin were used in 1971 for a production of 12.4 million tons of tinplate as compared with 75,700 tons used for a production of 11.8 million tons in 1970. The tin coating on steel varies with the product mix of tinplate plants, from 0.25 pound 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). Between 1966 and 1971, 19 new electrolytic tinplate lines have been added for an increase in capacity of 2.7 million tons. 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 to tinplate, an important characteristic for the recently introduced deep-drawn and wall-ironed can making process. Seamless cans could compete in the beer and beverage can market in which chrome-plated steel ('TFS') or aluminum have already acquired a strong foothold, increasingly replacing glass containers. This is a large and expanding market; for instance in 1971 total can shipments in the U.S. were 159 million base boxes, of which 37 million were for beer and 28 million were for soft drink containers. There is currently no substitute for tinplate in most container applications involving food processing and the expansion of this market particularly in less developed countries will continue. Despite yearly increases in absolute quantities of containers, the utilization of tin in tinplate has remained static in the past few years due mainly to more economical, thinner application of tin coatings. In the United States the tinplate industry for example utilized 11.34 pounds of tin per ton of tinplate in 1970 and 11.16 pounds in 1971. While most processed food products are now packed in cans manufactured from electrolytic tinplate, demand for H.D. (hot-dipped) tinplate material for canning highly corrosive foods such as fish remains strong in some countries. Poland, for example, will even increase H.D. tinplate production in 1972. In the developed countries, however, H.D. tinplate is being increasingly replaced by electrolytic, particularly by 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 23 per cent in 1971. Uses for tin solder (60-63%) in the electronic industry, are growing rapidly; tin remains unchallenged as the means for interconnecting components, giving utmost reliability. Newer applications are the mass-production of 'tailor-made' preforms based on discs and washers punched from foil and the use of a tin-lead powder and flux mixture that fuses on heat application. Tin and tin-rich coatings are also widely used for ensuring highest solderability.

Soft solders are used to join side seams of cans (2-3% Sn) and as lead-rich body-filling solders (2% Sn) in the automotive industry. Motor-car 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. Usage of solders in plumbing is important but is not increasing in proportion to gains in the construction industry because of the increased usage of PVC (polyvinyl chloride) plastics.

The alloy applications of tin have a long tradition. Babbitt and white metal alloy are used for 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% 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 about 28,000 tons of secondary tin. The gunmetals contain copper, tin and zinc and sometimes lead to improved machineability. 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. Pewter is again becoming more popular. Pewter plate and beaker castings for instance will commemorate the Munich 1972 Olympics. Modern methods of making pewterware from rolled sheet have recently been introduced. Pewter is pure tin hardened by the addition of copper and antimony; a representative composition is 91 per cent tin, 2 per cent copper and 7 per cent antimony.

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 jewelry.

As a minor alloying agent in other metals tin is widely used; for example alloy AP (anti-pollution) 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.

A relatively new application is the use of small quantities of tin in cast iron for engine blocks. Adding tin assures a uniformly hard, wear-resistant and thermally stable pearlitic structure in the castings. 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 conventional 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 from tinplate scrap.

Pure tin is used in collapsible tubes especially for pharmaceutical products. It is used as a molten bath in the float-glass process for making perfectly flat glass sheet. Tin is also marketed as tin oxide for polishing applications; a newer use of tin oxide is in the manufacture of conducting glass and glass resistors.

Tin is used widely in organotin coumpounds and inorganic tin compounds. Chemicals, however, account in total 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. In 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, a 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 used in the construction industry in piping, flooring and roofing materials, as well as in the packaging industry.

The high-purity tin produced in Canada by Cominco, 59 grade (99.999%) and 69 grade (99.9999%) 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.

Tariffs

Canada

Item No.		Most Favoured Nation
		(%)
32900-1	Tin in ores and concentrates	free
34300-1	Tin in blocks, pigs, bars, or granular form	free
34400-1	Tin strip waste and tin foil	free
33910-1	Collapsible tubes of tin or lead coated with tin	17½
38203-1	Sheet or strip, iron or steel, corrugated or not, coated with tin	12½
33507-1	Tin oxides	15
34200-1	Phosphor tin	7
43220-1	Manufactures of tin plate	17½

United States

Item No.		
601.48	Tin ore and black oxide of tin	free
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

		After January 1 1970	1971	1972
608.91	Tinplate and tin-coated sheets	8.5% valued at not over 9.4¢/lb	8% valued at not over 10¢/lb	8% valued at not over 10¢/lb
608.92	Tinplate and tin-coated sheets	0.8¢ per lb valued over 9.4¢/lb	0.8¢ per lb valued over 10¢/lb	0.8¢ per lb valued over 10¢/lb
644.15	Tin foil	24%	21%	17.5%

Sources: The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa. Tariff Schedules of the United States Annotated (1972) TC Publication 452.

Titanium and Titanium Dioxide

G.P. WIGLE

Quebec Iron and Titanium Corporation (QIT) treated 1,863,400 long tons of ilmenite in 1971 in producing 761,600 long tons of titania slag containing 70 to 72 per cent titanium dioxide and 535,300 long tons of coproduct iron. QIT is the only company in Canada mining and processing ilmenite ($FeOTiO_2$) for the production of titania slag used by manufacturers of sulphate-process titanium-dioxide pigment for the paint, paper and plastics industries.

Manufacturers of titanium-dioxide pigments are the major consumers of the growing annual output of the titanium minerals industry. Production of titanium metal and alloys is expanding with the requirements of industrial process applications and the aircraft industry.

World production of ilmenite ($FeOTiO_2$) increased from 2.2 million tons in 1960 to 3.8 million tons in 1971. The production of rutile, preferred by the makers of chloride-process titanium pigment, welding rod and titanium metal, increased from 114,200 tons to 430,000 tons in the same period.

Published prices for rutile, 96 per cent TiO_2 fob United States Atlantic and Great Lake ports, increased from U.S. $160 to $185 a short ton in 1970 and remained at $185 during 1971. The price of imported ilmenite, 54 per cent TiO_2, fob Atlantic ports was unchanged at U.S. $20-21 a long ton. Titania slag, 70 per cent TiO_2, fob producer's plant, increased from U.S. $45 to $48 a long ton early in 1971 where it remained during the rest of the year.

United States Government stockpiles of December 31, 1971 contained 56,525 short tons of rutile with a stockpile objective of 100,000 tons, and 35,015 short tons of titanium metal sponge with a stockpile objective of 33,500 tons.

Outlook

Growth of the titanium minerals industry is assured by the increasing requirements for titanium dioxide in the pigments industry and the use of titanium metal products in the aircraft industry and in industrial process applications.

The successful development of processes for the production of high-grade titanium dioxide (synthetic rutile) from ilmenite would have a regulating influence on the price of natural rutile concentrates, a restraint on the depletion of limited rutile reserves, and would expand the utilization of the more plentiful mineral ilmenite. Efforts are being made to develop and establish processes to upgrade ilmenite in the United States, Australia, Britain and Canada.

Rutile will remain in short supply; growth of ilmenite production will continue at about 5 per cent annually over the next several years because of the time required to bring new upgrading process facilities into production.

Production

Canada. Ilmenite is mined by open-pit methods in the Lac Tio-Lac Allard area of Quebec by Quebec Iron and Titanium Corporation. The ilmenite, crushed to minus 3 inches, is transported 27 miles by rail to Havre-Saint-Pierre and shipped up the St. Lawrence River to the company's beneficiation plant and smelter at Sorel near Montreal. The company owns one of the world's largest deposits of ilmenite, with reserves averaging 35 per cent TiO_2 and 40 per cent iron. The ilmenite occurs with finely disseminated hematite (Fe_2O_3) in dykes, irregular lenses and sill-like bodies within a large mass of anorthosite; it averages 86 per cent total oxides of titanium and iron and is upgraded, using heavy media, spirals and

Table 1. Canada, titanium production and trade, 1970-71

	1970		1971P	
	(short tons)	($)	(short tons)	($)
Production[1]				
Titanium dioxide	. .	34,622,589	. .	38,765,000
Imports				
Titanium dioxide pure				
United States	1,175	626,000	2,941	1,465,000
Britain	243	98,000	1,042	462,000
Belgium and Luxembourg	288	104,000	1,047	410,000
West Germany	1,026	467,000	575	258,000
Other countries	49	17,000	336	121,000
Total	2,781	1,312,000	5,941	2,716,000
Titanium dioxide extended				
United States	8,174	1,484,000	5,725	1,054,000
Titanium metal				
United States	275	2,327,000	123	1,144,000
Japan	9	26,000	49	267,000
Britain	4	69,000	4	141,000
Netherlands	1	2,000	1	2,000
Total	289	2,424,000	177	1,554,000
Exports[2] to the United States				
Titanium metal, unwrought, incl. waste and scrap	111	95,988	106[3]	122,941[3]
Titanium metal, wrought	434	2,418,112	97[3]	507,500[3]
Titanium dioxide	8,131	3,460,875	7,169[3]	2,858,171[3]

Source: Statistics Canada.
[1]Producer's shipment of slag. [2]U.S. Department of Commerce, Imports for Consumption, Report FT 135; no identifiable classes are available from Canadian export statistics. [3]11 months 1971.
PPreliminary; . . Not available.

cyclones, to 93 per cent combined oxides in the beneficiation plant. 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 molten iron. Pigment-grade slag contains 70 to 72 per cent TiO_2. The slag is tapped into slag-lined cars, cooled, solidified and then crushed to minus ½ inch. The iron, after tapping from the smelting unit, is superheated in an induction furnace, and desulphurized and carburized by a special ladle technique. Manganese and silicon may be added to make various grades of foundry pig iron. The iron is cast into forty-pound pigs.

Canadian Titanium Pigments Limited, a subsidiary of N L Industries, Inc., New York, produced titanium-dioxide pigment at Varennes, Quebec. The company operates a 30,000-ton-a-year sulphate-process plant and a 10,000-ton-a-year chloride-process unit. The main raw material for the sulphate process is titania slag from Quebec Iron and Titanium Corporation. The starting material for the chloride process is rutile concentrate from Australia.

Tioxide of Canada Limited, Sorel, Quebec, a subsidiary of British Titan Products Limited, operates a 33,000-ton-a-year sulphate process titanium-dioxide pigment plant. Much of the pigment production is sold in Canada but significant quantities are exported to Britain, Europe and the United States.

Titanium dioxide pigments are sold in three grades. Rutile and anatase grades are nearly pure titanium dioxide but differ in index of refraction and opacity due to difference in crystal structure. Extended titanium pigment containing 30 to 50 per cent titanium dioxide is also sold. Anatase and rutile pigments are produced in the sulphate process by using nucleating agents; only rutile-type pigments are produced in the chloride process.

Atlas Titanium Limited, Welland, Ontario, a subsidiary of Rio Algom Mines Limited, melts imported titanium ingot in a consumable electrode vacuum arc furnace and processes the metal into various mill products for sale in domestic and foreign markets. The company's titanium baskets are widely used in the nickel plating industry and its mill products are directed to both military and industrial uses.

Macro Division of Kennametal Inc., Port Coquitlam, British Columbia, manufactures titanium-carbide and tungsten-titanium-carbide powders and granules that are extensively used in cutting, grinding and drilling equipment and processes. The company specializes in a refining process in which hard metal carbides are precipitated from a metal melt and recovered by leaching the acid soluble matrix.

United States. The United States is the largest producer and consumer of ilmenite; it is also the largest consumer of rutile with most of its supply coming from Australia, the principal of the few producers of rutile. Ilmenite was produced in the United States at six mining operations in New York, Florida, Georgia, Virginia and New Jersey with over half of the total being produced in New York State and about one quarter in Florida. Domestic and imported ilmenite is consumed by some 18 firms of which five titanium pigment producers in the eastern United States use 99 per cent of the total. The United States has not produced rutile since 1968.

Australia. During the past ten years Australia has supplied about 90 per cent of the noncommunist world's rutile and about 11 per cent of the ilmenite concentrates. Australia's production of ilmenite concentrates increased to a record 865,570 long tons (969,438 short tons) in 1970. Rutile concentrate production reached a new high of 361,746 long tons (405,155 short tons).

Titanium dioxide processes, consumption, uses

The sulphate process is the process most commonly used in producing titanium-dioxide pigment but the chloride process is gaining importance in recent new production installations. Table 9 outlines the approximate capacity of the two processes in noncommunist countries.

Table 2. Titania slag and iron production, Quebec Iron and Titanium Corporation, 1966-71

(long tons)

	Ore Treated	Titania Slag Produced	Iron Produced
1966	1,129,200	468,500	315,600
1967	1,287,700	537,900	366,700
1968	1,445,900	600,800	410,100
1969	1,628,700	669,000	496,100
1970	1,862,400	754,200	531,200
1971	1,863,400	761,600	535,300

Source: QIT.

Table 3. Canadian titanium production trade and consumption 1962-71

(short tons)

	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]
1962	745,753	301,448	12,620	12,323	24,943	37,213	94
1963	915,360	379,320	3,367	9,319	12,686	37,480	78
1964	1,388,262	544,721	1,839	10,443	12,282	41,539	42
1965	1,318,402	545,916	1,565	9,534	11,099	39,682	65
1966	1,264,683	524,773	1,627	9,774	11,401	43,579	49
1967	1,442,238	602,455	1,616	9,763	11,379	43,447	54
1968	1,595,498	672,866	2,387	9,697	12,084	45,472	22
1969	1,844,255	749,234	2,504	8,651	11,155	47,419	34
1970	2,488,640	844,704	2,781	8,174	10,955	. .	27
1971[p]	. .	. .	5,941	5,725	11,666	. .	. .

Sources: Statistics Canada, and company reports.

[1]Producers' shipments of ilmenite from Lac Allard and St-Urbain areas, 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.

Pigment-grade TiO_2 is manufactured principally by the sulphate process in which finely ground ilmenite or titania slag (70 per cent TiO_2) is treated in sulphuric acid in large lead-lined concrete "digesters". The product is dissolved in water to give a solution of titanyl sulphate that contains iron sulphate and other soluble impurities, and unreacted solids in suspension. Following clarification and filtration, the titanyl sulphate solution is boiled in tanks to precipitate hydrated titanium oxide in a very fine crystalline state. The precipitated titanium oxide pulp is calcined in oil-fired rotary kilns reaching a final closely controlled temperature approaching 1,000°C. The calcined oxide is ground and classified to ensure fine particle size, then dried and packaged.

Ilmenite mined by Quebec Iron and Titanium Corporation does not lend itself directly to the sulphate process because of the fine hematite in the ilmenite that would consume an excessive amount of acid. The pyrometallurgical process carried out by QIT at Sorel removes iron and produces the high-titania slag that can be processed with low acid consumption.

The newer chloride process for producing titanium dioxide pigments uses titanium-bearing raw material, preferably rutile, mixed with carbon. The mixture is chlorinated at high temperature to produce titanium tetrachloride, a volatile colourless liquid, which is oxidized with air or oxygen to form titanium dioxide. The chlorine is recovered and recycled. Pigment production capacity using the chloride process has increased considerably since 1959.

Table 4. Salient titanium statistics, United States, 1970-71

(short tons)

	Ilmenite		Rutile		Titanium[1]	
	1970	1971[e]	1970	1971[e]	1970	1971[e]
Production	868,000	725,000	–	–	. .	. .
Imports	231,000[2]	150,000[2]	243,269	200,000	6,543	4,000
Consumption	1,098,000[2]	1,050,000[2]	188,290	170,000	16,414	12,500
Price/pound	. .	. .	9.3¢[4]	9.3¢[4]	$1.32	$1.32
Price/long ton	$20-21[3]	$20-21[3]	. .	. .	. .	. .

Source: U.S. Bureau of Mines, Commodity Data Summaries, January, 1972.

[1]Short tons sponge metal. [2]Includes titania slag from Canada. [3]54 per cent TiO_2, fob Atlantic seaboard. [4]fob Atlantic and Great Lakes ports.

[e]Estimated; . . Not available or not applicable; – Nil.

Table 5. Consumption of titanium concentrates in United States, by products, 1970

(short tons)

	Ilmenite[1]		Titania Slag		Rutile	
Product	Gross Weight	Estimated TiO_2 Content	Gross Weight	Estimated TiO_2 Content	Gross Weight	Estimated TiO_2 Content
Pigments	966,350	515,860	129,247	91,639	140,790	135,350
Titanium metals	–	–	–	–	(2)	(2)
Welding-rod coatings	510	356	(3)	(3)	15,634	14,917
Alloys and carbides	2,045	1,027	(3)	(3)	79	75
Ceramics	(2)	(2)	–	–	378	362
Glass fibres	–	–	–	–	(2)	(2)
Miscellaneous	21	13	–	–	31,409	29,938
Total	968,926	517,256	129,247	91,639	188,290	180,642

Source: U.S. Bureau of Mines, *Mineral Yearbook*, Preprint 1970.

[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.

– Nil.

Rutile (TiO_2) is favoured as the raw material in the production of titanium tetrachloride, which is the intermediate compound in the production of titanium metal and of TiO_2 pigment made by the chloride process. United States, in 1970, imported 243,269 tons of rutile concentrates, 92 per cent from Australia.

Table 6. Australian production and exports of ilmenite and rutile, 1969-70

	1969		1970	
	Concentrate	TiO_2 Content	Concentrate	TiO_2 Content
	(long tons)		(long tons)	
Ilmenite				
Production	701,172	380,219	865,570	464,347
Exports[1]	566,520	..	647,060	..
Leucoxene				
Production	7,970	6,996	10,317	9,072
Rutile				
Production	356,339	341,986	361,746	347,135
Exports	299,113	..	368,289	..

Source: Australian Mineral Industry, Quarterly Review.

[1]Includes leucoxene; .. Not available.

Table 7. Production of ilmenite concentrates by countries, 1969-71

	1969	1970	1971^e
	(thousands of short tons)		
Australia	794	977	950
United States	931	868	725
Canada[1]	749	845	853
Norway	541	638	650
Malaysia	146	212	620 (Malaysia to United Arab Republic)
Finland	152	167	
Ceylon	91	90	
India	57	87	
Spain	33	49	
Japan	6	9	
Portugal	0.6	0.2	
Brazil	22	–	
Republic of South Africa	18	–	
United Arab Republic	0.2		
Total	3,541	3,942	3,798

Sources: U.S. Bureau of Mines, *Minerals Yearbook*, Preprint 1970, Commodity Data Summaries, January 1972.

[1]Titania slag containing 72% TiO_2.

^{e}Estimated; – Nil.

Consumption of ilmenite is almost wholly confined to the sulphate process manufacture of TiO_2 pigment, which has largely replaced materials formerly used as white pigments. Minor amounts of ilmenite are used in the production of ferrotitanium, titanium carbide, and as a coating for welding rods.

Table 8. Production of rutile concentrates by countries, 1969-71

	1969	1970	1971^e
	(short tons)		
Australia	399,100	405,735	410,000
Sierra Leone	$31,379^r$	48,593	12,000
Ceylon	$3,036^r$	3,000	8,000 (Ceylon to Brazil)
India	2,751	2,756	
Republic of South Africa	543	–	
Brazil	10	–	
Total	436,819	460,084	430,000

Sources: U.S. Bureau of Mines, *Minerals Yearbook*, and Commodity Data Summaries.

^{e} Estimated; ^{r} Revised; – Nil.

Table 9. Estimated annual TiO_2 pigment production capacity by 1973

	Sulphate Process	Chloride Process
	(short tons)	
Argentina	15,000	
Australia	49,000	
Brazil	28,000	
Britain	165,000	70,000
Belgium	60,000	
Canada	57,000	10,000
Czechoslovakia	33,000	
Finland	30,000	
France	230,000	
West Germany	223,300	38,000
India	21,000	
Italy	149,000	30,000
Japan	205,300	30,000
Mexico	24,000	
Netherlands	40,000	
Norway	25,000	
Poland	30,000	
Portugal	6,000	
South Africa	27,000	
Spain	33,000	
United States	515,300	329,400
U.S.S.R.	20,000	
Yugoslavia	20,000	
Total	2,005,900	507,400

Source: Industrial Minerals, May 1971, published by *Metal Bulletin Ltd.*, London.

Table 10. United States, titanium metal data, 1965-69

(short tons)

	1966	1967	1968	1969	1970
Sponge metal					
Imports for consumption	5,225	7,144	3,443	6,332	6,543
Industry stocks	800	2,900	2,600	1,900	2,495
Government stocks (DPA inventories)	21,416	20,711	20,711	20,385	19,994
Consumption	19,677	20,062	14,237	20,124	16,414
Scrap metal consumption	4,857	5,822	4,701	7,566	7,242
Ingot[1]					
Production	24,253	25,960	19,234	28,490	24,331
Consumption	22,317	25,386	18,323	27,082	23,687
Net shipments of mill products[2]	13,996	13,634	11,900	15,940	14,499

Source: U.S. Bureau of Mines, *Minerals Yearbook 1970*, Preprint.
[1]Includes alloy constituents. [2]Bureau of the Census and Business and Defense Services Administration, Current Industrial Reports Series BDSAF-263.

Table 11. Canada, consumption of titanium dioxide and titanium dioxide pigments

	1967	1968	1969
	(short tons)		
Refined titanium dioxide			
Paint and varnish	25,629	27,413	27,841
Paper	4,206	4,776	4,986
Linoleum	1,174	843	1,064
Rubber	2,090	2,124	2,123
Miscellaneous non-metallic products	741	811	866
Plastic and synthetic resins	138	120	226
Toilet preparations	32	35	44
Industrial chemicals	105	57	79
Other chemicals	673	818	1,104
Extended titanium dioxide pigments, paint and varnish	8,658	8,473	8,812

Source: Statistics Canada.

Titanium metal

Titanium metal is a low-density, silver-grey metal and is important for its combination of lightness, strength and resistance to corrosion. The density of titanium is 0.164 pound per cubic inch compared with 0.28 for stainless steel. It is 60 per cent heavier than aluminum (0.10 lb/in^3) but only 55 per cent as heavy as alloy steel. Titanium alloys have strength and hardness approaching that of many alloy steels and the strength-to-weight ratio exceeds that of aluminum or stainless steel. The principal disadvantages in making use of this light metal are cost, fabrication difficulties, and reactivity at high temperature.

The growth in the utilization of titanium metal is shown in the consumption of sponge metal in the United States where sponge consumption was 5,487 tons in 1960, 12,105 tons in 1965, and 20,124 tons in 1970.

Titanium minerals

Ilmenite ($FeOTiO_2$) and rutile (TiO_2) are the only commercially important minerals of titanium. The titanium dioxide content of pure ilmenite is 53 per cent and that of pure rutile is 100 per cent. Titanium-bearing minerals such as anatase, leucoxene and brookite are associated with ilmenite and rutile and often comprise a small part of the marketed mineral concentrates. Ilmenite is recovered from alluvial and beach sands and from massive mineral deposits. The most important occurrences of rutile are in beach and alluvial sands but it is also found as a minor accessory mineral in rocks.

Prices

Prices in the United States published in Metals Week of December 20, 1971

	(U.S. $)
Titanium ore fob cars Atlantic ports, Great Lake ports	
Rutile, 96% per short ton delivered within 12 months	185
Ilmenite, 54%, per long ton, shiploads	20-21
Slag, 70% per long ton, fob shipping point	48
Titanium metal, sponge, per lb fob mine or mill max. 115 Brinell, 99.3%, 500 lb	1.32
Mill products per lb delivered, 4,000-lb lots	
Billet, Ti-6AL-4V (8" diam. random lengths)	2.81
Bar, Ti-6AL-4V (2" diam)	3.90

Prices (cont'd)

	(U.S. $)
Ferrotitanium, delivered	
Low carbon, per lb, Ti, 25-40%Ti	1.35
Medium carbon, net ton, 17-21% Ti	375
High carbon, net ton, 15-19%	310
Titanium dioxide, Canadian prices, quoted in Canadian chemical processing, of titanium pigments, effective December 1971	
Anatase, dry milled, bags, car lots, delivered, East, per 100 pounds	22.50
Anatase, regular, bags, car lots, delivered, East, per 100 pounds	25
Rutile pigment, bags, car lots, delivered, East, per 100 pounds	27

Tariffs

Canada

Item No.		British Preferential	Most Favoured Nation	General
			(%)	(%)
32900–1	Titanium ore	free	free	free
92825–1	Titanium oxides	free	12 ½	25
34715–1	Sponge and sponge briquettes, ingots, blooms, slabs, billets and castings in the rough, of titanium alloys for use in Canadian manufactures (expires 31 October 1974)	free	free	25
37506–1	Ferrotitanium	free	5	5
34735–1	Tubing of titanium or titanium alloys for use in Canadian manufactures (expires 31 January 1972)	free	free	25

United States

Item No.		On and After Jan. 1, 1971	On and After Jan. 1, 1972
		(%)	(%)
601.51	Titanium ore, including ilmenite, ilmenite sand, rutile and rutile sand	free	free
629.15	Titanium metal, unwrought, waste and scrap (duty on waste and scrap suspended on or before June 30, 1973)	18	18
629.20	Titanium metal, wrought	18	18
607.60	Ferrotitanium and ferrosilicon titanium	6	5
473.70	Titanium dioxide	9	7.5
422.30	Titanium compounds	9	7.5

Source: The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa. Tariff Schedules of the United States annotated (1971) TC Publication 344.

Tungsten

G.P. WIGLE

Canada Tungsten Mining Corporation Limited produced 2,608,030 pounds of contained tungsten (W) or 164,420 short ton units* of WO_3 in scheelite ($CaWO_4$) concentrates in 1971 compared with 2,955,725 pounds of contained tungsten or 186,340 short ton units of WO_3 in 1970. A total of 181,596 tons of ore containing 1.19 per cent WO_3 (tungstic oxide) was processed compared with 176,813 tons of ore averaging 1.39 per cent WO_3 processed in 1970. Recovery of scheelite was 76.39 per cent and 78.63 per cent in the respective years. Canada Tungsten estimated its ore reserves at the end of 1971 at 443,778 tons grading 1.36 per cent WO_3 and 107,882 tons grading 1.22 per cent WO_3 in a stockpile of crushed ore provided during the period of about three and a half months of open-pit mining conducted in the summer. The mine, mill and concentrator, employing some 70 persons, is at Tungsten in the Northwest Territories, near the Yukon border, about 135 miles north of Watson Lake.

Canex Tungsten Division of Placer Development Limited treated 172,512 tons of ore averaging 0.61 per cent WO_3 to produce 86,010 short ton units of WO_3 or 1,364,291 pounds of tungsten (W) contained in concentrates. The 500-ton-a-day Canex mill and concentrator near Salmo, east of Trail, in southeastern British Columbia, started operation in October 1970 and completed its first full production year in 1971. Reserves of broken and unbroken ore were 308,000 tons grading 0.67 per cent WO_3.

The Buchans Unit of Terra Nova Properties Limited, subsidiary of the Price Company Limited, suspended underground development work at its tungsten deposit at Grey River on the south coast of Newfoundland while conducting metallurgical testing to determine grade and recovery for feasibility studies. Initial test work showed that satisfactory concentrates could be made.

*A short ton unit is 20 pounds of WO_3 and contains 15.862 pounds of tungsten (W).

Markets and sources of supply

The only sales in 1971 from United States tungsten stockpile surplus material were 749,000 pounds of contained tungsten in concentrates sold in January. No satisfactory bids were received for tungsten concentrates offered for sale during the rest of the year. The General Services Administration maintained its base price of $55 a short ton unit of contained WO_3 in excess stockpile tungsten material offered for sale through the year. At December 31, 1971, there was approximately 69 million pounds of contained tungsten in United States stockpiles in excess of the stockpile objective of approximately 59 million pounds.

World production of tungsten in ores and concentrates of approximately 73 million pounds a year includes an estimated 36 million pounds produced by China, U.S.S.R. and North Korea. It should be noted that: sales from United States stockpile in 1969 at 38.2 million pounds of contained tungsten exceeded the annual production of either the noncommunist or the communist countries; stockpile sales in 1970 were 11.8 million pounds of tungsten; the United States had reversed its position in 1969 from that of an importer to that of a substantial net exporter of tungsten. Tungsten content of ores and concentrates exported from the United States was 7.15 million pounds in 1969 and 19.5 million pounds in 1970. Tungsten exports decreased to about 2 million pounds in 1971. United States tungsten imports for consumption in 1971 were 418,000 pounds compared with 1.3 million pounds in 1970; consumption of tungsten in concentrates was 11.6 million pounds compared with 16.7 million pounds in 1970.

Table I. Canada, tungsten production, imports and consumption, 1970-71

	1970		1971^p	
	(pounds)	($)	(pounds)	($)
Production[1] (WO_3)	3,854,800	. .	5,008,600	. .
Imports				
Tungsten in ores and concentrates				
United States	181,700	559,000	81,500	256,000
Mexico	–	–	41,800	117,000
Uganda	–	–	30,000	113,000
Thailand	500	1,000	–	–
Total	182,200	560,000	153,300	486,000
Ferrotungsten[2]				
Britain	152,000	452,000	148,000	338,000
United States	48,000	151,000	50,000	176,000
France	–	–	24,000	77,000
Total	200,000	603,000	222,000	591,000
Consumption (W content)				
Tungsten metal and metal powder	569,998	. .	. .	. .
Tungsten wire	19,738	. .	. .	. .
Other[3]	395,041	. .	. .	. .
Total	984,777	. .	. .	. .

Source: Statistics Canada.
[1]Mine production from company reports, WO_3 content. [2]Gross weight. [3]Includes tungsten ore, tungsten carbide powder, ferrotungsten and tungsten chemicals.
^{p}Preliminary; . . Not available; –Nil.

Table 2. Canada, tungsten production, trade and consumption, 1962-71

	Production[1] WO_3 Content	Imports: Tungsten Ore[3]	Imports: Ferro-tungsten[4]	Consumption, W Content
	(lb)	(lb)	(lb)	(lb)
1962	3,580	2,854,300	285,600	1,039,628
1963	1,224,305	645,500	624,100	903,924
1964	1,068,420	389,800	172,000	740,410
1965	3,824,660	357,400	354,000	877,614
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	3,854,800[2]	182,200	200,000	984,777
1971^p	5,008,600[2]	153,300	222,000	. .

Source: Statistics Canada.
[1]Producer's shipments of scheelite (WO_3 content). [2]From company reports. [3]Prior to 1964 reported in gross weight, commencing in 1964 in W content. [4]Gross weight.
^{p}Preliminary; . . Not available.

Outlook

Sustained demand and increasing prices prevailed in the world market for tungsten from 1963 to early in 1970. The average London price during 1963 was $8.79 a short ton unit of WO_3 and the average New York price was $8.70 a short ton unit of WO_3. The average published London price during 1970 was $70.40 while the United States stockpile sales price of $43 a short ton unit, established in March 1967, was increased to $55 in October 1970. The highest prices were attained in 1970 but a decline from the London high of $79.82 in February brought the year's average to $70.40 and was followed by a decline to about $38 in August 1971. It will be recalled that in 1963 the price was only about $8.70 a short ton unit of WO_3 and demand was at a similar low.

Stockpile sales in 1969 and 1970 totalled 50 million pounds of contained tungsten and came onto the market when world production was some 72 million pounds a year. Excess supply was accumulating in traders' and consumers' inventories in a period of reduced or stable demand and there remained in United States government stockpiles an excess of 68 million pounds over the objective of about 59 million pounds of contained tungsten. The effect is that if there is overproduction in a period of

Table 3. Tungsten production in ores and concentrates by countries, 1969-71

	1969	1970	1971e
	(thousands of pounds of contained tungsten)		
China[e]	17,600	17,600	17,600
U.S.S.R.[e]	14,300	14,800	14,300
United States	6,904	8,105	7,500
North Korea[e]	4,720	4,720	4,720
South Korea	4,345	4,564	4,600
Bolivia	4,059	4,068	4,100
Portugal	2,934	3,935	4,000
Canada[1]	4,064	3,855	5,009
Australia	2,756	2,743	2,975
Brazil	2,222	2,557	
Peru	1,519	1,823	
Thailand	1,442	1,567	
Japan	1,343	1,493	(10,067)
Mexico	635	586	
Spain	443	430	
Burma	353	419	
Other countries[e]	1,951	1,651	
Total	71,590	74,916	74,871

Sources: U.S. Bureau of Mines, *Minerals Yearbook* Preprint 1970; Commodity Data Summaries.
[1]From company reports; [e]Estimated; (10,067) Average of 1969 and 1970.

high economic activity, and unless production is reduced, the oversupply will be maintained until growth in demand overtakes the accumulation of supply. With the large amount of excess tungsten in government stockpiles the tungsten oversupply could extend for five years or more. However, if stockpile material is only obtainable at a fixed price that price should influence the market and help to maintain an orderly tungsten supply-demand relationship at reasonable prices.

Consumption and use

Demand for tungsten was reduced in 1971 in common with similar reduction in consumption of several other alloying metals such as molybdenum, columbium and vanadium.

United States consumption of tungsten in concentrates in 1971 was 11.6 million pounds compared with 16.7 million pounds in 1970. Tungsten was used in the form of: tungsten carbide, 35 per cent; metal powder, 32 per cent; ferrotungsten, 8 per cent; other tungsten materials, 25 per cent.

Tungsten carbide (WC) is the basic material for a great variety of cemented (or sintered) carbide cutting tools, dies and wear-resistant parts. The carbides are used for such tools as milling cutters, reamers, punches and drills; in dies for wire- and tube-drawing; and for wear-resistant parts of gauges, valve seats and guides. Large amounts are used by the mining industry in carbide-tipped rock-drill bits. The use of sintered carbide tire studs is contributing to the growing market for tungsten products. Flameplating and plasma-plating of coatings of tungsten carbide and cobalt are used to provide wear-resistant facings on metal parts. Tungsten carbide in tiny spherical pellets is used in ballpoint pens. Tungsten metal powder, made by hydrogen or carbon reduction of chemically produced oxide of tungsten, is used in making tungsten wire, rod and sheet, tungsten alloys and cast tungsten carbides.

In high-temperature nonferrous and superalloy fields, where temperature resistance requirements are beyond the ability of high-alloy steels, tungsten is used as a base-alloy with varying amounts of cobalt, chromium, molybdenum, nickel or other refractory metals to produce a series of hard, heat- and corrosion-resistant alloys. High-temperature alloys are used in structural components in temperature environments of 1,700°F and higher. High-tungsten alloys are used in jet and rocket engine parts, missile nose cone inserts, nozzle inserts, guidance vanes, turbine blades and combustion chamber liners. Examples of such applications are nose cone insert castings made of an alloy containing 85 per cent tungsten and 15 per cent molybdenum and rocket engine nozzle inserts of 98 per cent tungsten and 2 per cent molybdenum. Stellite, a nonferrous alloy containing from 5 to 20 per cent tungsten with cobalt and chromium, is used in welding rods for hard-facing and in high-speed tools.

Table 4. Consumption of tungsten by end uses in the United States, 1970

	(thousands of pounds of contained tungsten)	(%)
Steel		
Stainless and heat resisting	258	1.7
Alloy	185	1.2
Tool	1,475	9.6
Superalloys	265	1.7
Alloys (excluding alloy steel and superalloy)		
Cutting and wear-resistant material	7,028	45.8
Other alloys	549	3.6
Mill products made from metal powder	3,306	21.5
Chemical and ceramic uses	. .	. .
Miscellaneous and unspecified	2,292	14.9
Total	15,358	100.0

Source: United States Mineral Industry Survey, March 1971.
. . Not available.

Table 5. Consumption of tungsten in Canada by use, 1969-70

	1969	1970
	(lb of contained tungsten)	
Carbides	791,021	650,041
Alloy steels	195,244	285,937
Electrical and electronic	30,524	22,130
Other[1]	34,035	26,669
Total	1,050,824	984,777

Sources: Compiled in Mineral Resources Branch from data supplied by Statistics Canada.
[1] Includes nonferrous alloys, chemicals and pigments.

Ferrotungsten, used as an additive in the manufacture of alloy steels, usually contains from 70 to 80 per cent tungsten. Alloy tool steel classifications range through relatively low-alloy tool steels to intermediate and high-speed tool steels. The low alloys generally contain little or no tungsten, the intermediate class contains from 2 to 4 per cent tungsten and the high-speed tool steels contain from 1.5 to 18 per cent tungsten and other carbide-forming elements such as chromium, molybdenum and vanadium.

Pure or substantially pure tungsten is important in electric lighting, electronics and electrical contact applications. Tungstic acid, sodium tungstate, ammonium paratungstate and tungstic oxide are chemical forms produced at intermediate stages in manufacturing tungsten metal powder. Tungsten chemicals are used in textile dyes, paints, enamel and glassmaking.

Scheelite concentrate of sufficiently high grade and low in undesirable impurities can be used for direct addition to steel melts. Copper, arsenic, antimony, phosphorus, sulphur and manganese are the impurities that most often present a problem in meeting concentrate specifications. Some scheelite contains chemically combined copper and/or molybdenum which can be removed only by chemical treatment. Scheelite concentrates for direct addition to steel should have a minimum tungstic oxide (WO_3) content of 70 per cent. United States stockpile specifications for scheelite concentrates are outlined in Bulletin 630, issued by the U.S. Bureau of Mines in 1965; they call for a minimum WO_3 content of 65 per cent and low limits on the allowable content of many unwanted elements.

Among the principal consumers of tungsten in Canada are: *in Quebec*, Colt Industries (Canada) Ltd., Sorel; Shawinigan Chemicals Division of Gulf Oil Canada Limited, Montreal; *in Ontario*, Atlas Steels Division of Rio Algom Mines Limited, Welland; Canadian General Electric Company Limited, Toronto; A.C. Wickman, Limited, Toronto; Westinghouse Canada Limited, Hamilton; Fahralloy Canada Limited, Orillia; *in British Columbia*, Macro Division of Kennametal Inc., Port Coquitlam, Staymet Alloys Limited, Pitt Meadows.

Macro Division of Kennametal Inc. is the only Canadian manufacturer of tungsten-carbide powders, matrix powders for diamond-cutting tools, cemented carbide alloy powders and tungsten carbide hardfacing and cutting granules. The company specializes in a refining process in which hard metal carbides are precipitated from a high-temperature metal melt and recovered by leaching the acid-soluble metal binder. The raw materials used are scheelite and wolframite concentrates. Other Canadian consumers use partly processed and semifabricated tungsten products.

Minerals and occurrence

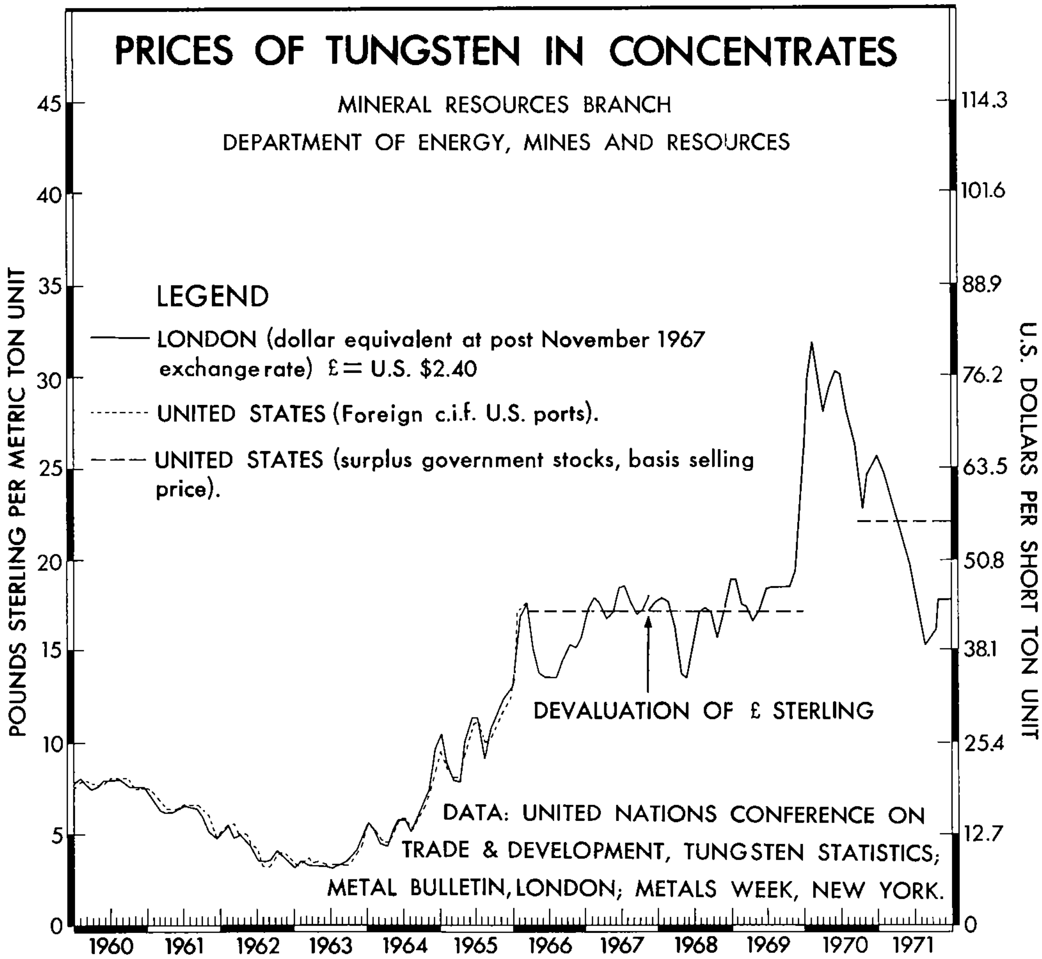
The most important ore minerals of tungsten are wolframite which is the collective name of a series of iron-manganese tungstates ($FeMnWO_4$), and the mineral scheelite which is nearly pure calcium tungstate ($CaWO_4$). Wolframite ($FeMnWO_4$) contains varying amounts of iron and manganese; the end-member of the series having less than 20 per cent manganese is the iron-tungstate called ferberite ($FeWO_4$) and the opposite end-member with less than 20 per cent iron is the manganese tungstate, hübnerite ($MnWO_4$). Wolframite varies in colour from dark grey to brown to black and contains from 76.3 to 76.5 per cent tungsten trioxide. Scheelite ($CaWO_4$) has an opaque wax-like appearance varying from white to pale yellow to brown and when pure contains 80.6 per cent tungsten trioxide. Scheelite is fluorescent in ultraviolet light, the colour varying from blue through white to yellow depending on the content of molybdenum which frequently replaces some of the tungsten in the mineral.

Tungsten is estimated to comprise about 0.0069 per cent of the earth's crust or about the same relative abundance as copper (0.0070%) and more than lead (0.0016%) or molybdenum (0.0015%).

In many tungsten-bearing mineral occurrences tungsten is the only valuable mineral constituent but tungsten, in important amounts, is also found associated with tin, molybdenum, gold, copper and silver-lead-zinc ores.

Tungsten mineral occurrences are found mostly in quartz veins and in contact-metamorphic deposits but pegmatite and placer deposits have also been productive. Disseminations of tungsten minerals in igneous rocks occur in many parts of the world but are rarely sufficiently concentrated to be of economic interest for tungsten alone. The tungstic oxide (WO_3) content of tungsten ore deposits seldom exceeds 2 per cent and is usually about 0.5 per cent.

Scheelite, occurring with pyrrhotite and chalcopyrite, is the ore mineral at Canada Tungsten's mining operation; the orebody occurs as a partial replacement body in a flat-lying, almost tabular skarn zone, about 70 feet thick, with altered limestone above and ribbon-chert below.



Prices

Tungsten prices according to Metals Week for December 1970 and 1971

	1970	1971
	(U.S. $)	(U.S. $)
Tungsten ore, 65% minimum WO_3 per stu of WO_3, duty included, GSA for U.S. market only		
Wolfram	55	55
Scheelite, $5.55 duty per stu of WO_3 effective Jan. 1, 1970, and to $4.76 per stu, effective Jan. 1, 1971	55	55
Ferrotungsten, per pound W, fob shipping point		
Low-molybdenum	3.65	4.60
High-molybdenum	3.65	. .
"UCAR" high-purity	3.86	. .
Dealer (export)	3.25-3.45	*(n)* 4.50
Tungsten metal, per pound, cif U.S. ports		
Carbon red, 98.8%, 1000 pound lots	3.06	4.50
Hydrogen red, depending on Fisher No. range	4.91-5.75	5.43-6.94
Typical Fisher No. 400	5.43	5.43

n Nominal; . . Not available.

Tariffs
Canada

Item No.		British Preferential	Most Favoured Nation	General
			(%)	(%)
32900–1	Tungsten ores and concentrates	free	free	free
34700–1	Tungsten metal in lumps, powder, ingots, blocks or bars and scrap of tungsten alloy metal	free	free	free
34710–1	Tungsten rod and tungsten wire	free	free	25
35120–1	Tungsten alloys in powder, pellets, scrap, ingots, sheets, strip plates, bars, rods, tubing, wire (expires October 31, 1971)	free	free	25
37506–1	Ferrotungsten	free	5	5
37520–1	Tungsten oxide in powder, lumps, briquettes	free	free	5
82900–1	Tungsten carbide in metal tubes	free	free	free

United States

Item No.		On and After Jan. 1, 1971	On and After Jan. 1, 1972
601.54	Tungsten ore, on pounds W content	30¢	25¢
	Tungsten metal unwrought other than alloys		
629.28	Lumps, grains, powders on pounds of W content	25¢ + 15% ad val	21¢ + 12.5% ad val
		%	%
629.29	Ingots and shot	12.5	10.5
629.30	Other tungsten unwrought metal	15	12.5
	Tungsten metal waste and scrap		
629.25	Not over 50% tungsten on pounds of W content	25¢ + 7.5%	21¢ + 6%
		%	%
629.26	Over 50% tungsten	12.5	10.5
629.35	Tungsten metal wrought	15	12.5
	Tungsten unwrought alloys		
629.32	Not over 50% tungsten on pounds of W content	25¢ + 7.5%	21¢ + 6%
629.33	Over 50% tungsten	15%	12.5%
		(¢) (%)	(¢) (%)
422.40	Tungsten carbide on pounds of W content	25 + 15	21 + 12.5
422.42	Other tungsten compounds on pounds of W content	25 + 12	21 + 10
607.65	Ferrotungsten on pounds of W content	25 + 7.5	21 + 6

Sources: The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa. Tariff Schedules of the United States Annotated (1971) TC Publication 344.

Uranium and Thorium

R.M. WILLIAMS

URANIUM

World* uranium markets softened further in 1971, as continued overproduction and intense competition combined to force uranium prices to an all-time low. Not unexpectedly, but despite increased sales efforts on the part of Canadian producers, not a single Canadian sale was announced. In response to the gloomy short-term outlook, world uranium exploration activity declined almost everywhere except in Australia, where attention continued to be focussed on recent discoveries in the Northern Territory.

The general decline in exploration raised concern in some circles that future additions to reserves will not be forthcoming in time to meet the requirements of the 1980's. Although the need for increased exploratory activity seems clear, an early reversal in the trend is not likely in view of the difficulty of financing exploration efforts from current sales of uranium. Consumers, however, were preoccupied in 1971 with other questions including the need for additional uranium enrichment capacity by the end of the decade and, in the United States, for an early solution to the nuclear power plant regulatory problem.

Some encouragement for uranium in the long term was apparent, however, with a continued surge in nuclear power plant orders and a reconfirmation of forecasts for long-term requirements. In this regard, in June 1971, the Canadian Nuclear Association predicted that requirements for uranium oxide (U_3O_8)** in the world could reach 219,000 tons of U_3O_8 a year by 1990, almost ten times present levels of production. Canada's own nuclear power program received a boost with the successful commissioning of the first two 540-MWe units of The Hydro-Electric Power Commission of Ontario's (Ontario Hydro) Pickering generating station.

Against this background, the level of Canadian uranium production is expected to change little until 1975 when a fourth producer, Gulf Minerals Canada Limited, will begin production in northern Saskatchewan. Thereafter, Canadian production should increase as the supply-demand situation comes more into balance and consumers move to assure themselves of continuing supplies of nuclear fuel. At some point toward the end of the decade, however, a shortage of uranium could develop, which will be particularly severe unless the current downward trend in exploration is soon reversed.

Production

Canadian uranium production rose by almost 9 per cent in 1971 to 4,976 tons of U_3O_8, of which about 4,100 tons were shipped. Some 85 per cent of this quantity came from Rio Algom Mines Limited and Denison Mines Limited which produce from quartz-pebble conglomerates in the Elliot Lake area of Ontario, while the remainder came from Eldorado Nuclear Limited which produces from pitchblende vein-type deposits near Uranium City, Saskatchewan. Together, the three operations employed some 2,100 workers during the year.

Denison's mill operated at an average of 4,128 tons of ore a day during 1971, or about two thirds of its nominal capacity; a total of 1,387,000 tons of ore were treated, with an average grade of 3.20 pounds

*"World" excludes U.S.S.R., eastern Europe and China, except where noted.

**1 short ton U_3O_8 = 770 kilograms of uranium metal.

Table 1. Uranium production in Canada by province, 1970-71

	1970		1971^p	
	(pounds)	($)	(pounds)	($)
U_3O_8 Shipments				
Ontario	6,676,841	..	7,000,000	..
Saskatchewan	1,531,893	..	1,200,000	..
Total	8,208,734	..	8,200,000	..

Sources: Statistics Canada for 1970; Mineral Resources Branch for 1971.
^{p}Preliminary; .. Not available for publication.

U_3O_8 per ton, to produce 4,256,000 pounds of U_3O_8. The company's program of underground mechanization continued, with considerable success, resulting in a productivity increase per mining manshift of more than 30 per cent in the past two years. Mining was again concentrated in the northeast section of the mine while some efforts were also spent in commencing development of the conveyor system which will service the next major part of Denison's reserves, east of the present workings. On surface, work continued towards enlarging the waste disposal area together with the appropriate ancillary effluent treatment facilities. Finally, with its output now secure until the end of the decade, the company was in a position to continue its planning for the inevitable expansion of its operations in the post-1975 period. Metallurgical-design work has been all but completed for expansion of its mill to a capacity of some 7,500 tons of ore a day and the company expects to begin engineering design work in 1972.

Rio Algom's Quirke mill operated in excess of its nominal 4,500-ton capacity, averaging 4,587 tons of ore per day throughout the year. A total of 1,564,000 tons of ore was treated, with an average recovered grade of 2.90 pounds of U_3O_8 per ton, to produce 4,492,000 pounds of U_3O_8; average mill recovery was

Table 2. Uranium production by major producing countries, 1961-71

	Canada	United States	South Africa	Other[1]	Australia	France[2]	Total[3]
				(short tons U_3O_8)			
1961	9,641 $195,691,624	17,399	5,468	223	1,400	2,141	36,272
1962	8,430 $158,183,669	17,010	5,024	80	1,300	2,603	34,447
1963	8,352 $136,909,119	14,218	4,532	86[4]	1,200	2,692	31,080
1964	7,285 $ 83,509,429	11,847	4,445	144	370	2,113	26,204
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	12,338	3,883	295	330	2,235	22,782
1969	3,854 $ 53,150,657	$10,934^r$	3,979	288^r	330	$2,245^r$	$21,630^r$
1970	$4,104^r$ ..	$12,768^r$	4,119	330	330	2,149	23,800
1971^p	4,100 ..	12,800	4,000	350	110[5]	2,550	23,910

Sources: Statistics Canada; U.S. Bureau of Mines, *Minerals Yearbook 1969,* and U.S. Commodity Data Summaries, January 1972; and South African Chamber of Mines *Eightieth Annual Report, 1969.*
[1]Includes Argentina, Portugal, Spain and Sweden; 1961 also includes Finland. [2]Includes Gabon, Malagasy Republic (until 1967) and Niger (from 1970). [3]Totals are of listed figures only. Other countries are known to have produced small quantities of uranium and estimates have been included in totals for year 1964 and earlier, in tables of this series in previous reviews. [4]Estimate for Spain. [5]Estimate, production ceased April 1971.
^{p}Preliminary; ^{r}Revised; .. Not available for publication.

95 per cent*. Output from the company's New Quirke mine was gradually increased so that by year-end it was operating at some 6,200 tons per day, well in excess of its original design capacity (the old Quirke mine was depleted and closed at year-end). Production has progressed well and, with the increasing ore thicknesses now being encountered, the company is experimenting with various forms of trackless mechanization, which could be integrated into its established track-haulage system. Rio Algom is also in the midst of completing a major enlargement of its waste disposal area and ancillary effluent treatment facilities. Operation of the Quirke mill has been extremely successful at the new enlarged capacity and planning is now being directed toward further expansion of the mill, perhaps to 6,500 tons of ore per day. Such an expansion, together with rehabilitation of the Panel mine, located some 5 miles to the east, will be necessary as markets expand in the post-1975 period.

Eldorado completed the third year of its planned five-year program of reduced production. The 2,000-ton-a-day mill operated at about 50 per cent capacity with considerable improvement in recoveries as a result of the major conversion of its leaching circuit completed in 1970; a total of 219,391 tons of ore was treated, with an average recovery of 5.49 pounds of U_3O_8 per ton, to produce 1,204,406 pounds of U_3O_8. In the main Fay mine, preparations were completed for the sinking of the new internal shalf, and sinking was well under way by year-end. Planning and design work also proceeded for a new Fay mine heating plant and for new effluent treatment facilities required to comply with more stringent regulations. Stoping began early in 1971 at the new Hab mine located some 7 miles northeast of the main Fay complex and the output, which is being trucked to the mill, increased throughout the year. Operations were suspended temporarily at the Eldorado complex during a 58-day strike which lasted from late August to early November.

Gulf Minerals' Rabbit Lake project, near the west side of Wollaston Lake in northern Saskatchewan, saw increased activity in 1971. Site preparation was completed during the summer season and engineering design of the mill and surface plant was well advanced. Plant construction was to commence in the spring of 1972, and completion is scheduled for late 1974 with first production at a rate of 2,000 tons of ore a day for early 1975; it will be an open pit operation. By year-end the Saskatchewan government had completed constructing some 40 miles of the new $17-million, 150-mile highway which will extend from Southend at the south tip of Reindeer Lake to the Gulf project. Plans for the proposed Collins Bay townsite, to be located six miles north of Rabbit Lake on the west side of Wollaston Lake, were still under discussion at year-end.

*Rio Algom delivered 3,013,000 pounds of U_3O_8.

Development work at Agnew Lake Mines Limited's property, 30 miles west of Sudbury, was suspended as announced in late 1970. Salvage of underground equipment and materials, and mothballing of the surface plant was completed by the spring of 1971; the mine will be allowed to flood. Although the operation had reached an advanced stage of underground development, construction of the proposed 3,000 ton-a-day mill had not begun, and the company* decided to redirect its efforts elsewhere pending negotiation of a suitable sales contract.

Exploration

Uranium exploration activity in Canada declined further in 1971 and almost no new activity was reported. Indeed, in 1971 only two new uranium exploration permits were issued by the Atomic Energy Control Board (AECB), compared with 17 in 1970 and 82 in 1969. Moreover, revocation of an additional 58 permits was granted, leaving only about 85 out of the total 220 permits issued since January 1967 still in force; of these perhaps 25 per cent are inactive. The decline in uranium exploration can be largely attributed to the poor short-term market outlook but concern by companies as to what the final outcome of the Federal Government's ownership requirements will be, has also been a contributing factor. Virtually the only major uranium exploration programs still under way in Canada are those being carried out on ground held by companies prior to the Government's March 2, 1970 announcement relative to ownership. An increase in exploration is not expected before the short-term market outlook improves and the new ownership legislation is promulgated.

In eastern Canada, British Newfoundland Exploration Limited (Brinex) continued its efforts, with its West German partners, in the Makkovik-Kaipokok area of Labrador, although on a reduced scale. Some very minor activity was evident in the Maritimes and also in the Mont-Laurier area of Quebec. Activity in the Elliot Lake-Agnew Lake area of Ontario was significantly reduced.

In western Canada, Mokta (Canada) Ltée continued its efforts in the Carswell dome area of northern Saskatchewan and Gulf Minerals carried on with its program along the Wollaston Lake trend. Some continued activity was also reported by New Continental Oil Company of Canada Limited in the Baker Lake area, Northwest Territories and by Vestor Explorations Ltd. on its Simpson Islands project in the

*Kerr Addison Mines Limited, which controls 80 per cent of the Agnew Lake project, is developing a uranium orebody in the Grants area of New Mexico, in partnership with Noranda Mines Limited.

east arm of Great Slave Lake. No activity of significance was reported from the Uranium City area of Saskatchewan.

The decline in uranium exploration activity was not unique to Canada. In the United States, the United States Atomic Energy Commission (USAEC) estimated that uranium exploration and development drilling would fall from 23.5 million in 1970 to about 17.6 million feet in 1971, or a 40 per cent decline from the peak year in 1969. In spite of exploration expenditures of $225 million spent in the past five years in the United States, no entirely new significant uranium districts have been discovered. Moreover, the discovery rate during the past five years has only been about 3.5 pounds of U_3O_8 per foot of drilling, somewhat less than half the historical rate. Despite these declining efforts however, the USAEC was able to announce in early 1971 significant increases in United States reserves.

Table 3. United States reserves and resources of uranium

	As of January 1	
	1970	1971
	(short tons of U_3O_8)	
Reserves		
Up to $8/lb	204,000	246,000
Up to $10/lb	250,000	300,000[1]
Potential resources		
Up to $8/lb	385,000	490,000
Up to $10/lb	600,000	680,000

[1]Does not include 90,000 tons of U_3O_8 available to the year 2000 as byproduct of copper and phosphoric acid production.

Of particular interest to South Africa was an announcement made in June by Dr. A. J. A. Roux, President of South Africa's Atomic Energy Board, that following a revaluation of its uranium reserves, reasonably assured resources recoverable at up to $10 per pound U_3O_8 had been increased from 200,000 to 300,000 tons of U_3O_8. "The increase has resulted from new discoveries in both the Republic and South West Africa, as well as from the achievement of higher extraction efficiencies coupled with the development of improved extraction processes."

Despite the general decline in worldwide uranium exploration, considerable activity continued to be reported from Australia. Late in 1970 Noranda Australia Ltd. announced a uranium discovery in the Alligator Rivers uranium field of the Northern Territory, a northeasterly trending belt about 75 miles long some 150 miles east of Darwin. Although Noranda has announced detailed results of its drilling program on the Jim Jim project no reserve estimates have been made. Reserve estimates of Queensland Mines Limited's Nabarlek deposit, located in the north part of the trend, were revised drastically downward in August from the originally reported 55,000 tons of U_3O_8 to just under 9,000 tons of U_3O_8. The figures were subsequently adjusted upwards to about 10,000 tons; grade is now around 2 per cent U_3O_8 in contrast to the original report of 27 per cent U_3O_8. Evaluation of Peko-Wallsend Ltd's Ranger deposit continued in 1971 and the reserve estimates remained at 70,000 tons of U_3O_8. All three deposits occur at pitchblende veins and desseminations in Lower Proterozoic metasediments. Other Australian activity was reported from the Westmoreland district in northwestern Queensland and from the Lake Frome area in South Australia.

In the longer term, it is clear that the level in exploration effort must increase significantly beyond that of recent years. As a result of worldwide programs between 1967 and 1970, net additions to world reserves (reasonably assured resources at up to $10 per pound U_3O_8) have been around 50,000 tons of U_3O_8 per year. It has been estimated that cumulative world requirements* for uranium will increase to 500,000 tons of U_3O_8 in 1980, 1,600,000 tons by 1990 and to perhaps 3,000,000 tons by the year 2000. Assuming that an eight-year forward reserve is maintained, it can be shown that net annual additions to reserves must approach 150,000 tons of U_3O_8 per year within 10 years. Such an exploration effort will require exploration expenditures of about $300 million per year. The present declining rate of exploration is in clear contrast to these longer-term requirements and, should the declining trend persist, the possibility that a shortage of uranium will develop in the 1980's is real.

Government affairs

Denison began deliveries in mid-1971 under the new joint-venture stockpiling agreement announced in December 1970 by the Federal Government. Under the agreement, Denison will deliver to the stockpile 2,000,000 pounds of U_3O_8 each year from 1971 to 1973 and up to 467,000 pounds in 1974; the assumed value of the material will be $6 per pound of U_3O_8, of which the Government will pay Denison approximately $4.56 per pound. The Government's total expenditure will not exceed $29.5 million. Upon sale of the stockpiled material and recovery of all associated costs, net revenues will be shared on a pro rata basis up to the amount of the respective contributions; net revenues then remaining will be shared equally.

During the stockpiling period, 1971 to 1974, Denison will have the option of meeting new contracts

*Davis, Michael. *Uranium Supply and Demand*, NATO Advanced Study Institute on Methods of Prospecting for Uranium Minerals, London, September 1971.

from its existing inventory or from mine production. In the latter case, deliveries to the joint-venture stockpile will be correspondingly decreased. After December 1974, however, Denison will service any new sales from its remaining inventory and from the joint-venture stockpile on a pro rata basis; consequently, mine production will not be increased until both the joint-venture stockpile and Denison's inventory are depleted.

The agreement helps to assure a stable economy in the Elliot Lake community until Denison's long-term sales contracts begin to carry its full operation beginning in 1975. A new federal Crown corporation, Uranium Canada Limited, has been formed to act as management agent for the Government in this joint stockpile activity. The stockpile will be located at Port Hope, Ontario, and maintained by Eldorado Nuclear Limited, on a contractual basis.

In May 1971, the Honourable J. J. Greene led a mining mission composed of government officials to Australia, for the purpose of discussing common problems of mineral development and investment, including foreign participation and international commodity marketing. Also on the agenda were questions relating to the uranium industry and the current instability in prices in the international marketplace.

Australia was also proceeding with efforts to limit the extent of foreign ownership in its uranium industry. In late 1970 the Prime Minister of Australia announced that his government intended to limit the number of shares held by persons not ordinarily resident in Australia, or by foreign corporations, in both Queensland Mines Limited and Kathleen Investments (Australia) Limited (which owns 50 per cent of Queensland), to 15 per cent in the aggregate and to 5 per cent for any single investor. Moreover, he indicated that nominees holding in excess of 5 per cent of the issued shares in these companies would be required to disclose the beneficial ownership of those shares.

In February 1971 Australia's Minister of National Development announced that quantities of uranium exported from Australia would no longer be restricted. Government approval of all export contracts will continue to be a requirement, however, to ensure that adequate domestic supplies are maintained, that export prices are satisfactory, and that Australian uranium is used only for peaceful purposes.

In May 1971 the United States Environmental Protection Agency (EPA) announced its conclusion that the proposed radiation standard of 4 working level months (WLM)* for underground uranium mines should not be altered. Although the new standard was scheduled for enforcement as of July 1, 1971, a variance provision was subsequently announced whereby operators who demonstrated their intent to meet the new standard as soon as possible would be granted up to six months to comply. The previous radiation standard was 12 WLM per year. Although Canadian radiation standards were still set at 12 WLM per year, producers were operating at levels within or approaching the new United States standard.

*A working level is any combination of short-lived radon daughters in one litre of air that will result in the ultimate emission of 1.3×10^5 MeV of potential alpha energy; a working level month expresses a miner's calculated exposure to radon daughter products found in the mine air.

Table 4. Major Canadian uranium commitments announced since 1966

	Total Quantity as of January 1972
	(tons U_3O_8)
Britain	11,500[1]
Canada	7,700
Japan	33,100
West Germany	15,100
Other	500
Total	67,900[2]

[1]Includes delivery options. [2]A market for an additional 7,000 tons U_3O_8 has been guaranteed by Uranerzbergbau GmbH and Co. K. G. but remains uncommitted.

Markets

Competition in world uranium markets was intense in 1971 and, despite increased efforts on the part of Canadian producers, not a single Canadian contract was announced. Late in the year, however, Rio Algom announced that letters of intent had been signed for the sale of an additional 1,000,000 pounds of U_3O_8 for delivery in the 1972 to 1974 period from its Elliot Lake operation. Since late 1966 Canadian producers have negotiated contracts totalling almost 68,000 tons of U_3O_8 for deliveries into the early 1980's. Of the 68,000-ton total some 6,200 tons of U_3O_8 had been delivered to the end of 1971. In addition, some 200 tons of U_3O_8 remained to be delivered by Rio Algom to Britain under the old 'master' contract (1962 UKAEA option); this contract was to be completed early in 1972.

Market activity during the year, outside of the United States, was largely confined to Japan and West Germany. Although some contracts were successfully negotiated few details were reported; the principal successful bidders were RTZ Mineral Services Limited of London, URANEX* of France and Nuclear Fuels Corporation of South Africa (Pty) Ltd. (NUFCOR).

*A commercial uranium marketing consortium, controlled 34 per cent by the Commissariat à l'Energie Atomique (CÉA), 33 per cent by Compagnie Française des Minerais d'Uranium, and 33 per cent by Société Minière Pechiney-Mokta.

Table 5. Exports of uranium concentrates from Canada, 1961-71

	United States	Britain	West Germany	Japan	Others	Total
			(thousands of dollars)			
1961	173,914	18,256	513	40	–	192,723
1962	149,165	16,598	206	40	–	166,009
1963	96,879	40,509	–	130	13[1]	137,531
1964	34,863	39,627	159	4	–	74,653
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[2]	8,990	–	–	–	26,021
1971[p]	5,899[2]	11,473	–	315	–	17,687

Source: Statistics Canada, exports of radioactive ores and concentrates that cleared customs.
[1]Brazil. [2]Almost entirely destined for a third country, following enrichment, primarily West Germany and Japan.
[p]Preliminary; – Nil.

Of the successful contracts, the following came to light. Early in 1971 RTZ announced the sale of 1,100 tons of U_3O_8 to West Germany's Kernkraftwerk Brunsbüttel for delivery in the mid-1970's; the uranium will come from Australia's Mary Kathleen Uranium Limited. Later it was reported that URANEX and NUFCOR had split an order for the initial core of Belgium's Tihange power plant and that URANEX will supply the full second core. In mid-1971, URANEX completed negotiations with Kansai Electric Power Co., Inc., of Japan, for the sale of 6,300 tons of U_3O_8 for delivery from 1974 to 1986 in the form of UF_6. Finally, in September, it was reported that NUFCOR and West Germany's Urangesellschaft GmbH will each provide 550 tons of U_3O_8 toward the initial core and reload at Austria's Tullnerfeld plant, for delivery from 1974 to 1979.

Prices on the non-United States market were reported to be in the range of \$5.50 to \$6.50 per pound U_3O_8 for delivery in the mid-1970's and in some cases below \$5 per pound U_3O_8 for delivery before 1975. In the protected climate of the United States market prices remained some \$0.50 to \$1 per pound higher.

In May 1971 the USAEC published the results of its annual Nuclear Industry Fuel Supply Survey. As of February 1, 1971 a total of 108,600 tons of U_3O_8 had been committed by United States producers to domestic buyers to 1988; some 19,200 tons of this was delivered by the end of 1970. In addition, a total of 6,300 tons of U_3O_8 had been sold to foreign buyers, of which 4,400 tons had been delivered by the end of 1970. The survey illustrated that 60 per cent of the commitments were made to utilities and 40 per cent to reactor manufacturers, the reverse of three years ago. Of the 85,200 MWe of capacity covered in the study, some 86 per cent of first-core uranium supply arrangements had been made, while only 44 per cent had been made for the fourth reload (about four years after startup). Arrangements for only a small fraction of subsequent reloads had been made, thus illustrating that United States uranium procurement commitments are of a comparatively short-term nature.

The United States market, which represents roughly one half of the growing world market for uranium, has been effectively closed to non-United States producers since 1964 through a USAEC restriction on the enrichment of foreign uranium for domestic use. To the dismay of foreign producers, the USAEC announced on October 13, 1971 its intention to postpone the removal of its restriction until the late 1970's; removal had been expected on a phased basis beginning as early as 1973. Moreover, to the dismay of all producers, the USAEC also announced its intention to commence disposal of the 50,000-ton U_3O_8 surplus from its uranium stockpile, beginning in 1974. It was proposed that the uranium be made available to domestic and foreign customers alike, on a bid basis, and that deliveries in the domestic market in any year not exceed one half of the projected cumulative growth in domestic requirements from 1973 to and including that year, nor would they exceed one fourth of the total domestic requirements in any such year. Comments on both proposals were solicited by the USAEC for consideration prior to publication of its proposed plan, probably early in 1972.

Refining

In response to the growing market for uranium hexafluoride (UF_6), Eldorado Nuclear Limited has completed the first stage of expansion of the UF_6

section of its refinery at Port Hope, Ontario. The capacity of the plant, which was initially 2,150 tons of U (in the form of UF_6) a year, was boosted in midyear to 2,750 tons U per year by the addition of six flourine cells. A further expansion to some 5,000 tons U per year is planned and will be carried out as sales develop. It is expected that the second expansion will be required for 1974 production; it will take some 15 months to complete. Despite the 1971 expansion, production of UF_6 was cut back temporarily late in the year because of slippages in customers' reactor programs.

Although competition for UF_6 conversion business has been keen amongst the five major world refiners, Eldorado was successful in obtaining new contracts in 1971, totalling about 6,700 tons of U (as UF_6) for delivery from 1971 to 1978. This brought total commitments to some 11,000 tons U, of which 55 per cent is for United States customers and the remainder for customers in Japan, West Germany and Sweden. At year-end negotiations were under way which could double these commitments.

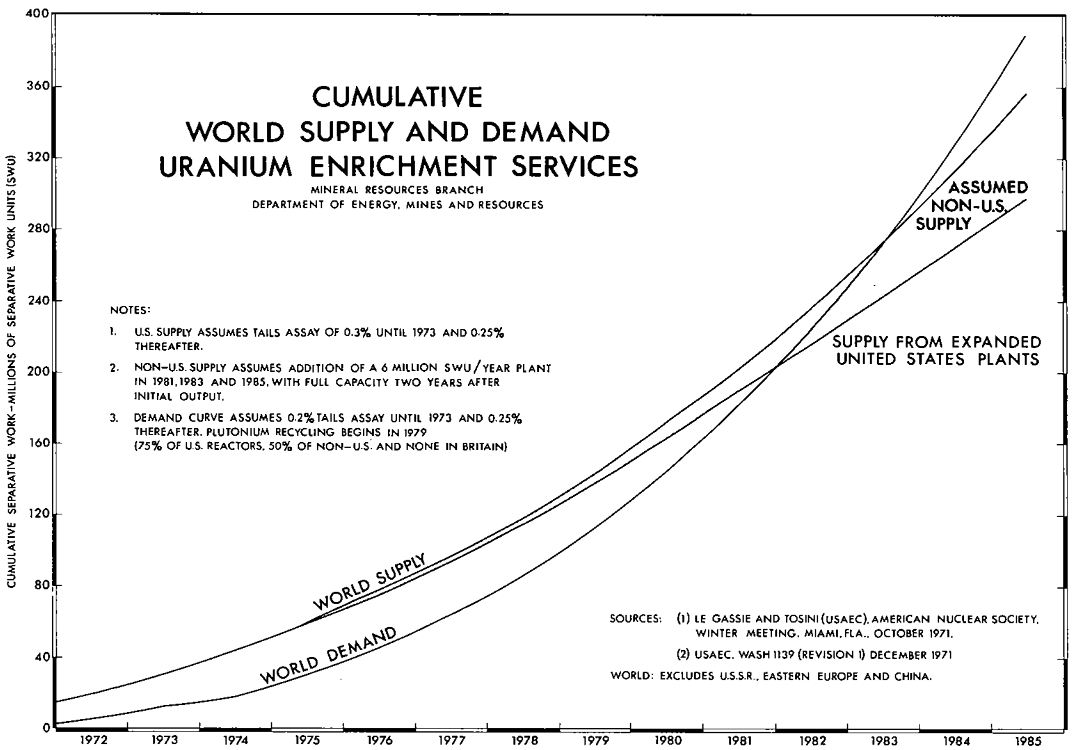
Production of natural ceramic uranium dioxide (UO_2) continued at a high level (continuous processing equipment was installed in 1970) and production of enriched UO_2, from enriched UF_6 brought in from the United States, reached an all-time high. The latter material was primarily refined for Atomic Energy of Canada Limited's research reactor requirements. Development work also continued in the field of high-density nuclear fuel, particularly uranium carbide, and important advances were made. Eldorado's program toward the marketing of spent fuel casks, fabricated from depleted uranium, made progress; container design and acceptance for licensing should be completed early in 1972.

Enrichment*

Problems in the yellowcake market were overshadowed in 1971 by the pressing need for an early decision to construct additional uranium enrichment capacity somewhere in the world. Clearly, existing capacity, over 95 per cent of which is in the United States, even with the planned programs of expansion and preproduction, will not be sufficient to meet world requirements much beyond the end of the decade. One of the largest hurdles, aside from the problem of raising up to $1,500 million and supplying a power source up to 2,000 MWe, is the choice and availability of the enrichment technology.

In this regard, the Commissariat à l'Énergie Atomique (CÉA) of France was attempting in early 1971

*See 1970 mineral review of uranium and thorium for background.



to organize a multinational government-industry consortium to construct in Europe a $600-million plant of 6 million separative work units (SWU) per year, based on French gaseous diffusion technology. The CEA engaged Bechtel Corp. of San Francisco and Société Technip of France to carry out a site and cost study, with a view to commencing construction in 1974.

In June 1971 the United States initiated a program to transfer information on its uranium enrichment technology to United States industry, and the USAEC invited proposals from interested companies toward programs in research and development of technology for enriching uranium and for manufacturing enriching systems equipment. Originally it was intended to make a primary selection of 25 companies followed by a final selection of about 10. Despite two extensions of the deadline for applications, only 22 proposals were received; all 22 companies were chosen to take part in the first stage of the program.

In July 1971 the United States announced its willingness to undertake discussions with other nations relative to the possible use of United States gaseous diffusion technology in a multinational uranium enrichment plant. Two meetings were subsequently held in November 1971, which were attended by representatives of Australia, Canada, Japan, Britain and members of the European Economic Community. The talks were described as extremely preliminary and further informal talks amongst interested parties were proposed prior to a third exploratory meeting with the United States early in 1972.

The possibility of locating an enrichment plant in Canada has drawn considerable interest in some circles. In March 1971, Brinco Limited, formerly British Newfoundland Corporation Limited, asked the federal government if it would support a Brinco initiative to locate such a plant in Canada. The company would likely wish to locate the plant in Labrador as part of comprehensive scheme to develop the power potential of the Lower Churchill Falls.

In Europe, under the British-Dutch-West German Tripartite Agreement signed in 1970 for the development of the centrifuge enrichment process, two new companies were formed, owned in equal shares by the three parties. Centec GmbH, which will act as the 'Prime Contractor', is headquartered in Bensburg near Cologne, West Germany, and will be responsible for co-ordinating the integrated centrifuge research and development program, designing and building centrifuges and constructing enrichment plants. The Uranium Enrichment Company Ltd. (URENCO), based at Marlow-on-Thames near London, England will purchase plants from Centec, operate them through subsidiaries, and market the enriched uranium. Demonstration plants using the new centrifuge process are currently under construction at two sites. A plant at Almelo, Netherlands is being built in two parts, each with a capacity of 25,000 SWU per year, one using Dutch and the other using German technology; the Dutch section is to be commissioned in early 1972 and the German section about a year later. The second plant will have an ultimate capacity of about 50,000 SWU per year and is being constructed at Capenhurst, England, for commissioning in January 1973.

Of particular interest in 1971 was an agreement between the CEA and the Soviet agency Tech Nas Export for the enrichment of some 80 tons of French yellowcake at a price of $26 per SWU. This was the first uranium enrichment contract the Soviets have negotiated outside the Soviet bloc.

On February 22, 1971 the USAEC's charge for uranium enrichment services was increased from $26 to $28.70 per SWU. The charge was to be increased again to $32 per SWU on September 6, 1971 primarily because of rising costs of electrical power, but did not come into effect until November 14 following Phase I of President Nixon's wage-price freeze.

On July 1, 1971 a new operating 'tails' asway of 0.3 per cent U^{235} went into effect at USAEC enrichment plants; the new assay will be maintained during fiscal years 1972 and 1973. Transactions with customers, however, will continue on the basis of the 0.2 per cent U^{235} assay and the necessary increased feed is being supplied from USAEC stocks. The USAEC suggested that customers plan for an assay of 0.25 per cent U^{235} for transactions after fiscal year 1973.

In late 1971 the USAEC announced plans to increase the termination charges and the advance notice period of customers who terminate contracts with the Commission for uranium enrichment services. The termination charge will increase to 40 per cent of the established charge for each unit of separative work terminated and the required notice period will now be five years. Current regulations provide for a graduated termination payment up to 25 per cent for services terminated without 3½ years advance notice. The change was necessary to facilitate future planning for expansion of facilities and contracting for the associated electric power supply. The first of two major expansions to USAEC enrichment facilities was initiated in mid-1971. The $500 to $600 million Cascade Improvement Program (CIP) will involve various technological improvements to the system, without the need for an increased power supply, and will increase total capacity by some 27 per cent.

Nuclear developments

World nuclear power plant orders exceeded 40,000 MWe in 1971, representing capital cost commitments on the part of electric utilities in excess of $10,000 million. As of the end of 1971 there were over 22,000 MWe of nuclear capacity in operation in the world, which together, in December, produced about 12,000 million kwh of electricity. It is expected that by the year 1990 some 60 per cent of the electricity

Table 6. Estimated growth of world nuclear capacity

	Net Electrical Output Installed by End of Year				
	1970	1975	1980	1985	1990
	(MWe)	(MWe)	(MWe)	(MWe)	(MWe)
Canada	480	2,500	7,000	16,000	35,000
United States	6,850	64,000	165,000	300,000	500,000
Western Europe	10,000	30,000	92,000	197,000	320,000
Japan	1,290	7,000	27,000	60,000	120,000
Other countries	380	3,000	17,000	55,000	120,000
World (excl. nes[1] countries)[2]	19,000	106,500	308,000	628,000	1,095,000
Countries nes	1,200	5,500	42,000	104,000	235,000
Total, world	20,200	112,000	350,000	732,000	1,330,000

Source: Merlin, H. B., *Nuclear Energy its Growth and Impact,* Canadian Nuclear Association, June 1971.
[1]nes (not elsewhere stated), including U.S.S.R., eastern Europe and China. [2]Reactor mix used for Table 8: after 1975, PWR's and BWR's – 40 to 42%; CANDU-PHWR's – 4% in 1975 to 11% in 1990; HTR's – 7% in 1985 and 1990; AGR's and MAGNOX – those now in operation or under construction.

produced in the major industrialized countries will be from nuclear fuel.

Nuclear power in Canada reached a milestone in 1971 with the first two units of the Pickering Nuclear Generating Station reaching full power before year-end.* The capacity factor for Unit One during the last seven months of 1971 was 76 per cent, while that for Unit Two during the last two months of 1971 was 90 per cent; nuclear generation provided 13 per cent of Ontario Hydro's electricity during December, traditionally one of Ontario's heaviest demand periods.

Ontario Hydro's Douglas Point Station, continued to operate successfully, and during July produced more electricity than any other unit of comparable size in the world. Commissioning of The Quebec Hydro-Electric Commission's (Hydro-Québec) Gentilly Station continued, and full-power output was expected early in 1972. Experimental operation of the Nuclear Power Demonstration Station (NPD) as a boiling heavy water (BHW) reactor was concluded in April and the reactor is now being operated in the pressurized-water mode to produce cobalt-60 as well as power. The Canadian-built Karachi Nuclear Station went critical early in 1971 and had reached a level output of some 40 MWe by year-end.

The Canadian General Electric Company (CGE) heavy water production plant at Point Tupper, Nova Scotia resumed operation in May 1971 after a brief shutdown for repairs; operation of the 400-ton-a-year plant has continued on a gradually increased basis. Construction of Atomic Energy of Canada Limited's (AECL) 800-ton-a-year heavy water production plant at the Bruce Nuclear Power Complex continued on schedule, with first production expected in 1972. In October 1971 an agreement was reached between the Government of Canada and the Government of Nova Scotia whereby AECL was given responsibility for the rehabilitation and subsequent operation of Deuterium of Canada Limited's heavy water production plant at Glace Bay, Nova Scotia. The project will require an estimated $95 million and first production is expected in 1975. Heavy water to meet Canadian needs has continued to be in short supply, requiring AECL to purchase some of its interim needs in the United States, Sweden and the U.S.S.R. Canadian production should be sufficient to reverse this shortage by 1974.

Canadian efforts to sell its nuclear power system abroad continued throughout the year. Mexico terminated the first round of negotiations for the supply of a 600-MWe unit late in 1970 and Australia discontinued negotiations with suppliers for its intended 500-MWe unit in April 1971; AECL had bid on both. At year-end Mexico, Romania, Italy and Argentina were still viewed as prospective areas. In the case of Argentina, AECL was considering submitting a turn-key bid, together with an Italian partner, for a 600-MWe unit to be built at Córdoba for 1978 start-up.

Outlook

The surge in nuclear plant orders which was evident in 1971, not only in the United States but also to a lesser extent in western Europe and Japan, was due to several factors. Faced with increasing costs and uncertainties in the supply of fossil fuels, together with stricter environmental controls over conventional thermal power plants, utilities were giving increasing preference to nuclear plants. Moreover, in response to the various construction and licensing delays, utilities were extending lead-times for nuclear orders to 8 or

*Unit Two reached full power on November 7, 1971, just seven weeks after start-up.

Table 7. Canadian natural uranium heavy water power reactors in operation or under construction

Name	Type	Capacity	Location	Status
		(MWe)		
NPD	PHW	22	Rolphton, Ontario	Operating since 1962
Douglas Point	PHW	208	Kincardine, Ontario	Operating since 1967
Pickering	PHW	4 x 508	Pickering, Ontario	Units one and two at full power, 1971; Unit three critical, 1972
Gentilly	BLW	250	Gentilly, Quebec	Commissioning; full power, 1972
Bruce	PHW	4 x 750	Kincardine, Ontario	Under construction
RAPP	PHW	2 x 203	Rajasthan, India	First unit critical, 1972
KANUPP	PHW	125	Karachi, Pakistan	Commissioning
	Total	6,043		

Table 8. Annual and cumulative demand for uranium at the mill head[1]

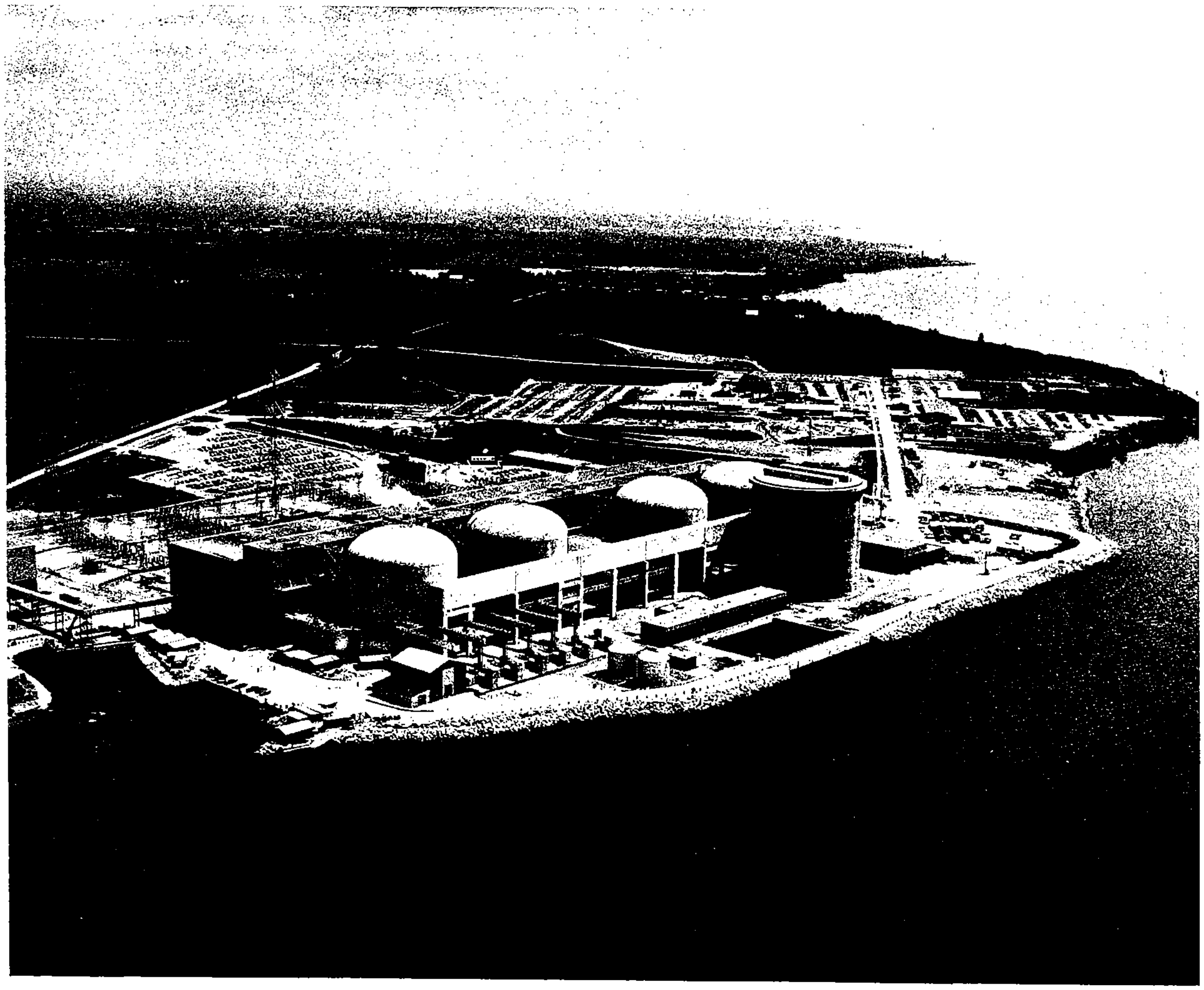
	1970	1975	1980	1985	1990
	(tons of U_3O_8)				
Annual demand					
Canada	200	550	1,400	3,000	6,000
United States	7,800	20,000	42,000	71,000	108,000
Japan	500	2,850	6,600	16,000	27,000
Western Europe	2,700	12,000	23,000	39,000	57,000
Other	–	1,300	4,000	12,000	21,000
World total	11,200	36,700	77,000	141,000	219,000
Cumulative demand					
Canada	200	2,000	7,000	18,000	42,000
United States	7,800	75,000	240,000	530,000	1,000,000
Japan	500	9,000	37,000	100,000	210,000
Western Europe	2,700	37,000	130,000	290,000	545,000
Other	–	3,000	15,000	62,000	153,000
World total	11,200	126,000	429,000	1,000,000	1,950,000

Source: Merlin, H.B., *Nuclear Energy, its Growth and Impact,* Canadian Nuclear Association, June 1971.
[1]No allowance for breeders or for plutonium recycle; tails assay of 0.2% U^{235} assumed for enriched fuel cycles.
– Nil.

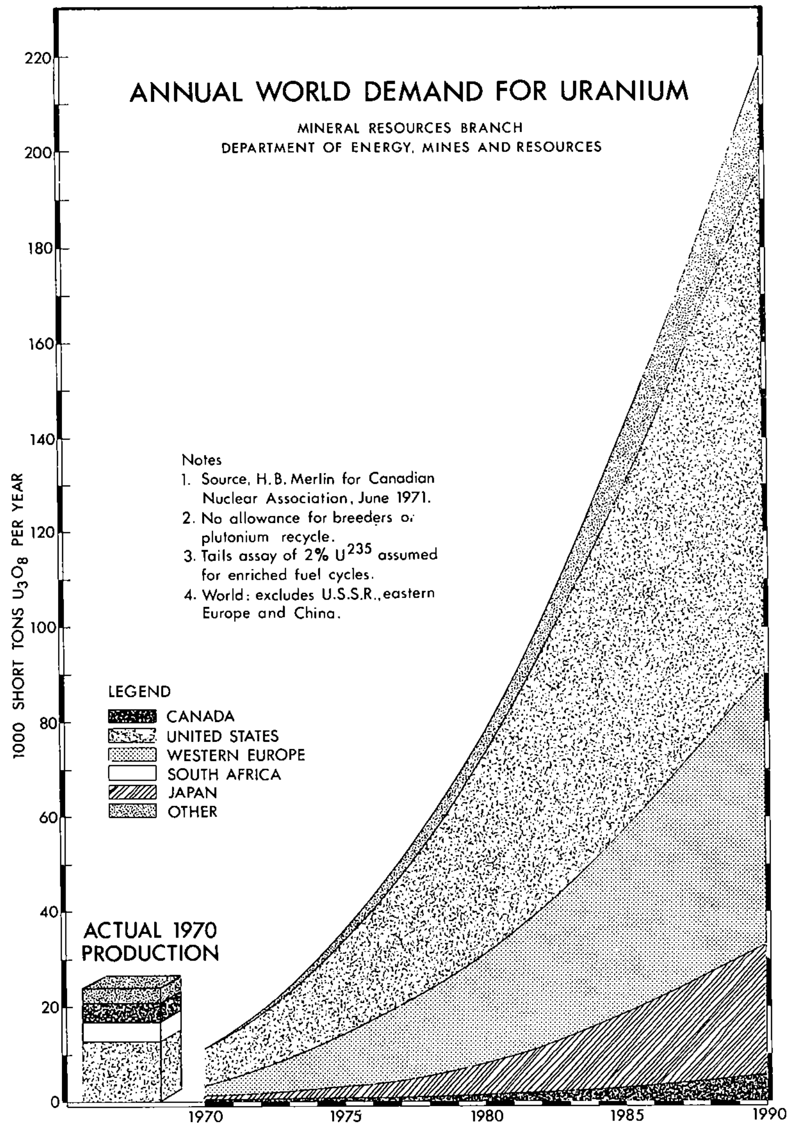
even 9 years. Reactor manufacturers expected that 1972 nuclear plant orders in the United States alone might reach 35,000 MWe, greatly exceeding the 26,000-MWe record set in 1967.

Two new long-term forecasts of world requirements for uranium were released in 1971, one by the Canadian Nuclear Association (CNA) and one by the USAEC. The USAEC's forecast was in close agreement with the CNA's prediction that annual world requirements will rise to 77,000 tons U_3O_8 in 1980, 141,000 tons in 1985 and perhaps reach 219,000 tons in 1990. Plutonium recycling, which is expected to begin in the late 1970's, will decrease these requirements by about 10 per cent in the mid-1980's and perhaps by 15 to 20 per cent by 1990. The advent of breeder reactors, which will also decrease these requirements, is not expected until the mid-1980's at the earliest, and according to some authorities not until the 1990's. In short, it would appear that the uranium industry can look forward to an increasing demand for its product, averaging some 15 per cent a year over the next 20 years.

In the short term, however, requirements have largely been filled to the end of 1974. Indeed, due to construction and licensing delays some customers were seeking a deferral of deliveries, and others had built up sizeable inventories. For Canadian producers, Japan and western Europe continue to be the most promising markets, and negotiations were under way with several potential customers at year-end. Japan has



Ontario Hydro's 2032 MWe Pickering Nuclear Generating Station at Pickering, Ontario. (Courtesy of Atomic Energy of Canada Limited.)



made commitments for perhaps 50 per cent of its requirements to 1985, largely through long-term contracts. As noted earlier, it may be late in the decade before Canadian producers will be allowed to compete in United States markets.

On the supply side, continued overproduction has added to the world uranium surplus, which is now variously estimated at between 75,000 and 100,000 tons of U_3O_8. This surplus, in government stockpiles and producer and consumer inventories, together with the existing excess in production capability, has precipitated intense competition, particularly in the non-United States market, and prices have declined to extremely low levels. These short-term factors are reflected in the declining rate of uranium exploration activity, particularly in Canada and the United States, a discouraging trend in view of the magnitude of projected requirements.

Clearly, new mining and milling capacity now in the planning stage will not be sufficient to meet requirements to the end of the decade. Even with a phased disposal of the various stockpiles and inventories, substantial additional capacity will be needed to meet the demands of the 1980's, and most of it will be dependent on the discovery and development of new reserves. Without a significant increase in exploratory activity, a shortage of uranium could well develop in the early 1980's.

In conclusion, little improvement is expected in the market situation for 1972. Canadian uranium production will remain stable until 1975 at which time Gulf's Rabbit Lake operation will commence production. No increase in Canadian uranium exploratory activity is foreseen until the short-term market improves and the new ownership legislation is promulgated. Hopefully, these factors will be short-lived and, as the market stabilizes and prices show some improvement, the industry will again be encouraged to rally to the challenge of meeting the growing requirements for nuclear fuel.

THORIUM

There was no production of thorium in Canada again in 1971. Until mid-1968, the Nuclear Products Department of Rio Algom Mines Limited had produced thorium concentrates as a byproduct of uranium at its Nordic mill in Elliot Lake, Ontario; the plant had a capacity to produce 150 to 200 tons of thorium oxide (ThO_2)* a year. Production was suspended in July 1968 with the closure of the Nordic mill. Because of poor market conditions for thorium and rare earths** it was decided that a transfer of the thorium recovery circuit from Nordic to Quirke was not justified at that time. The last shipments of thorium concentrate made from the company's inventory were made in 1969; the concentrate was a thorium sulphate ('thorium cake') and graded from 35 to 40 per cent ThO_2.

Since thorium production began at Elliot Lake in March 1959, Rio Algom's principal customer has been Thorium Ltd., in Britain. Small quantities have also been delivered from time to time, in the form of metallurgical-grade thorium oxide (99.8+ per cent ThO_2), to Chromasco Corporation Limited (formerly Dominion Magnesium Limited), Haley, Ontario, which produced sintered pellets of pure (98 per cent) thorium and thorium powder (99.5 per cent).

Canadian resources of thorium are associated with both the conglomeratic ores of the Elliot Lake-Agnew Lake areas and the pegmatitic ores of the Bancroft area. Data compiled in connection with a recent assessment of Canada's uranium resources, made by the Department of Energy, Mines and Resources, suggest conservatively that reasonably assured resources of ThO_2, associated with uranium reserves in the \$10 a pound U_3O_8 category, exceed 100,000 tons of ThO_2. Further details concerning Canada's production of thorium can be found in previous issues of this series.

Present world production of thorium is primarily as a byproduct of the chemical processing of monazite beach sands for their rare-earth content. The leading producers of monazite are Australia, Brazil, India, Malaysia and the United States. The principal non-energy uses of thorium continue to be in the manufacture of gas light mantles, of thorium-magnesium alloys, and of dispersion-hardened alloys of nickel, cobalt, tungsten and molybdenum. Demand for thorium for industrial uses has changed little in recent years and, although some growth can be expected in the 1970's through new uses, is expected to remain relatively small, perhaps rising to no more than a few hundred tons a year.

The greatest potential use for thorium, however, is as a nuclear fuel for advanced converter- and breeder-type reactors. Although thorium (Th^{232}) is not a fissile material like U^{235}, it is a fertile material and can be converted into fissionable uranium-233(U^{233}) under irradiation. The use of this Th^{232}-U^{233} fuel cycle has many potential advantages and research programs are under way in some countries, including Canada, to develop this technology. Of particular interest as potential users of this fuel cycle are the Canadian CANDU reactor and the high-temperature, gas-cooled reactor (HTGR) being developed in the United States. A 40-MWe demonstration HTGR has been in operation at Peach Bottom, Pennsylvania since 1966 and a 330-MWe prototype HTGR is under construction at Fort St. Vrain, Colorado for start-up in 1972; the system is being developed by Gulf

*1 short ton ThO_2 = 795 kilograms of thorium metal.
**Rare earths were also recovered with thorium as a byproduct of uranium; see 1971 review, "Rare Earths".

General Atomics Co. (GGA), the nuclear energy subsidiary of Gulf Oil Corporation.

The commercial acceptance of the GGA system became a realization in August 1971, when Philadelphia Electric Company placed an order for two 1,160-MWe units, the first unit for 1978 start-up. In December, another United States utility, Delmarva Power & Light Company, ordered two 770-MWe units, the initial unit also for 1978 completion. The HTGR system has a net operation efficiency significantly higher than United States light water reactors and its good environmental characteristics are viewed by some as possible aides to the reactor licensing dilemma faced in the United States. To illustrate the potential thorium requirements of GGA's HTGR, the initial core for a 1,000-MWe unit uses 40 tons of ThO_2 and refueling (after the second year) uses 10 tons of ThO_2 per year*.

Despite the advantages of the Th^{232}-U^{233} fuel cycle and the probable ultimate success of the fuel technology, the growing availability of plutonium from conventional reactors will dictate its use either for recycling or, in the 1980's, as fuel (with uranium) for fast breeder reactors. Consequently, while successful penetration of reactors like the HTGR into the nuclear power market can be expected to increase the demand for thorium significantly, requirements will probably rise to no more than a few thousand tons of ThO_2 a year by the latter part of the century.

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*Woodmamsee, W. C., Thorium, *Engineering and Mining Journal,* March 1972.

Vanadium

D.D. BROWN

The principal vanadium-producing countries are the United States, Republic of South Africa, Southwest Africa, Finland and Norway. The production of these countries in 1971 was an estimated 12,966 tons of vanadium contained in ores, concentrates and vanadium pentoxide (V_2O_5).

Vanadium was recovered in Canada during 1971, in small amounts from crude oil in the form of vanadium pentoxide (V_2O_5) by Petrofina Canada Ltd. at its oil refinery near Point-aux-Trembles, Quebec. The Petrofina byproduct plant, with a capacity of about 100 short tons of contained vanadium a year, recovered vanadium from fly ash, collected from the burning of petroleum coke produced and used in the oil refining process.

Prices of dealer technical grade V_2O_5 in the United States decreased in 1971 from $2 a pound in January to $1.55 in late March and $1.50 in July where it stayed for the remainder of the year. Standard ferrovanadium was priced at $4.12 a pound of contained vanadium and Carvan was priced at $3.48 a pound of contained vanadium during 1971. A new ferrovanadium alloy, Ferovan, was sold at $3.68 per pound of contained vanadium.

No offers or sales of vanadium from United States Government stocks were made by the General Services Administration in 1971. In August 1971 the disposal of 1,200 tons of vanadium from government stocks was authorized. During 1971, the United States strategic stockpile contained 2,400 tons of ferrovanadium and 4,258 tons of vanadium pentoxide.

Outlook

Increasing demand for vanadium in high-strength, low-alloy (HSLA) steels, tool steels, carbon steel castings and in titanium alloys have accounted for past growth. Following reduced world consumption of vanadium during 1971 as a result of a generally decreased level of steel production, the annual consumption growth rate of vanadium is expected to exceed the annual growth rate of steel because of the growing and more widespread use of this metal in steel production. Long-term demand forecasts of about 5 per cent a year in the United States and 3 to 4 per cent a year for the rest of the world to year 2000 have been made. No world supply problems are anticipated since reserves of known producers are sufficient to meet long-term demands.

Production and consumption

Canada. Petrofina Canada Ltd. started vanadium recovery from Venezuelan crude residues in 1965 and suspended production during 1971. The fractional distillation step in the oil refining process removes the lighter components of the crude and leaves a residual fuel that can be used as bunker oil or for asphalt production or in the manufacture of petroleum coke. Most of the vanadium occurring in some crude oils is concentrated in the residual fuel product. The part in the coke can be recovered from the fly ash formed in burning the powdered coke as a fuel component, with oil or gas used in producing steam for the fractional distillation process. The fly ash, which may contain 10 per cent or more V_2O_5, is recovered in electrostatic precipitators and then leached in sulphuric acid. The slurry formed is filtered and vanadium pentoxide is separated from the filtrate by oxidation with sodium chlorate and precipitation with ammonia. The V_2O_5 is dried, fused and cast into flakes containing 99 per cent vanadium pentoxide.

Table 1. Canada, vanadium imports and consumption, 1970-71

	1970 (short tons)	1970 ($)	1971^p (short tons)	1971^p ($)
Imports				
Ferrovanadium				
Austria	–	–	36	276,000
United States	188	937,000	42	223,000
Britain	–	–	21	97,000
Total	188	937,000	99	596,000
Consumption				
Ferrovanadium				
Gross weight	374	..	..	..
Vanadium content	255	..	..	..

Source: Statistics Canada.
^{p} Preliminary; – Nil; .. Not available.

Masterloy Products Limited, near Ottawa, Ontario, has produced ferrovanadium by the aluminothermic process at its ferroalloy plant since 1966. In mid-1971, the company started vanadium recovery, in the form of vanadium pentoxide at its newly constructed ferroalloy plant addition. Two forms of vanadium-enriched raw materials used are sodium fluorovanadate and fly ash. Sodium fluorovanadate is obtained as a residue precipitated from the Aluminum Company of Canada, Limited (Alcan) bauxite leading circuit at Arvida, Quebec. Fly ash, a flue dust, is obtained from thermal power stations. The sodium fluorovanadate and fly ash fused with soda ash are digested in sulphuric acid in a simple agitator before passing over a pressure drum filter. Precipitation with an ammonium salt gives a filter cake of ammonium metavanadate, which is calcined and fused to yield flakes of vanadium pentoxide.

Canada's imports of ferrovanadium in the six years from 1964 to 1969 were 2,407 tons valued at $7.9 million. Imports of ferrovanadium dropped to 188 tons in 1970 and 99 tons in 1971 compared with an average of 401 tons during the previous six-year period.

United States. Estimated noncommunist world production of vanadium in 1971 was 10,021 tons with the United States being the largest producer and consumer. Consumption in 1971 decreased to 4,685 tons (V content) compared with 5,039 tons in 1970 and 6,154 tons in 1969. Exports of ferrovanadium decreased from 2,154 tons (gross weight) in 1970 to 676 tons in 1971 and exports of vanadium in ore, concentrates, pentoxide, oxide and vanadates decreased to 260 tons (V content) from 972 tons in 1970.

The iron and steel industry used about 80 per cent of the vanadium consumed, nonferrous alloys used 8 per cent, and chemicals, catalysts and other uses the balance.

United States production of vanadium is recovered as a byproduct of uranium production of mines in the Colorado plateau, of phosphorus production from phosphate rock in Idaho, and as a primary product from a vanadium-bearing clay mining operation at Wilson Springs, Arkansas.

Republic of South Africa. The Republic of South Africa produced 4,363 tons of vanadium pentoxide in 1971 compared with 4,323 tons during 1970. The Vantra Division of Highveld Steel and Vanadium Corporation Limited near Witbank in eastern Transvaal recovers V_2O_5 by chemical treatment of the slag in the processing of vanadium-bearing titaniferous magnetite mined from the Bushveld igneous complex. Highveld's integrated iron, steel and vanadium production complex, also near Witbank, came into operation during 1968. Vanadium pentoxide is extracted from slag produced in the iron plant with the slag containing approximately 28 per cent V_2O_5, 10 per cent TiO_2, 42 per cent FeO and 20 per cent SiO_2. Ore reserves are estimated at 200 million tons containing 55 to 57 per cent iron, 12 to 15 per cent titanium oxide and 1.4 to 1.9 per cent vanadium pentoxide. Capacity production by Highveld Steel and Vanadium Corporation Limited would contain about 11,500 tons a year of V_2O_5.

Norway and Finland. The noncommunist world's other main vanadium sources are Finland and Norway, where vanadium is obtained as a byproduct in the processing of magnetite iron ores.

Table 2. World production of vanadium in ores and concentrates, 1968-71

	1968	1969	1970^r	1971^e
	(st)	(st)	(st)	(st)
United States	6,483	5,577	5,319	5,548
Republic of South Africa	2,498	2,873	2,420	2,443
Finland	1,321	1,484	1,450	450
Norway	940^r	1,010^r	1,080	1,080
Southwest Africa	630^r	500^r	400	400
France	100	100	100	100
Total	11,972	11,544	10,769	10,021

Source: U.S. Bureau of Mines, *Minerals Yearbook 1970*; estimates for 1971 from various sources.
^{e} Estimated; ^{r} Revised.

Products and uses

Vanadium is a steel-grey metallic element with a melting point of 1,900°C (3,450°F). Technical-grade vanadium pentoxide (V_2O_5) is the common product of primary vanadium producers and is available as fused black oxide containing 86 to 99 per cent V_2O_5 and as an air-dried powder containing 83 to 86 per cent V_2O_5. Chemical grades of vanadium pentoxide have typical V_2O_5 contents of 99.5 to 99.9 per cent. Ammonium metavanadate (NH_4VO_3) and sodium vanadates are supplied to the chemical industry.

Vanadium is used principally as the ferroalloy ferrovanadium in the iron and steel industry. Its function is to reduce and control grain size to impart toughness, strength and impact resistance, and to maintain hardness at elevated temperatures. Vanadium increases the yield strengths of low-alloy steels and weight reductions can be effected in structural applications in comparison with traditional carbon steels. Vanadium in quantities of 0.03 to 0.07 per cent alloys is used by steelmakers to increase the hardenability of low-alloy carbon-manganese-boron steels and to eliminate the softening effect of tempering and welding. Vanadium contents of high-strength oil and gas transmission lines are up to 0.08 per cent. Tool steels typically include vanadium contents of 0.20 per cent to 5.0 per cent, with high-speed steels generally in the higher vanadium content levels. In tool steels the functions of vanadium are to increase hardenability and to resist softening and grain growth during tempering.

Ferrovanadium, a ferroalloy additive, is an alloy of iron and vanadium with silicon or carbon or both. Different grades of ferrovanadium are available with vanadium contents varying from 35 per cent to 85 per cent, carbon from 0.50 to 2.0 per cent and silicon from 0.50 to 11 per cent. Union Carbide Corporation produces "Carvan" which contains 83 to 86 per cent vanadium, 10 to 13 per cent carbon and only 1 to 3 per cent iron. Solvan, another vanadium ferroalloy, contains 25 to 30 per cent vanadium, maximums of 0.8 to 5 per cent silicon and a maximum of 0.30 per cent carbon.

Table 3. Vanadium consumed in the United States, 1970-71

	1970	1971
	(pounds of vanadium)	
Ferrovanadium	8,501,373	8,180,911
Oxide	217,208	218,340
Ammonium metavanadate	87,367	71,347
Other	1,223,178	903,081
Total	10,029,016	9,373,679

Source: U.S. Bureau of Mines, Mineral Industry Surveys.

Table 4. Vanadium consumed in the United States by end-use, 1970-71

	1970[r]	1971
	(short tons of vanadium)	
Steel		
High-speed tool	472	440
Stainless	47	30
Alloy (excluding stainless and tool)	2,394	2,470
Carbon	1,031	830
Other steel	33	35
Cast iron	47	14
Welding and hardfacing rods and materials	9	11
Magnetic alloys	1	
Nonferrous alloys	466	372
Chemical and ceramic uses	100	82
Miscellaneous and unspecified	439	401
Total	5,039	4,685

Source: U.S. Bureau of Mines, Mineral Industry Surveys, 1970 and 1971.
[r] Revised.

Ferrovanadium is produced by reducing vanadium pentoxide with reducing agents such as carbon and silicon in an electric furnace and by reducing vanadium pentoxide with aluminum in an ignition furnace of the aluminothermic process. Scrap iron and fluxes are included in the charge.

Vanadium is generally added to iron and steel with other alloying elements rather than alone. Titanium-base vanadium alloys, having high-temperature strength qualities and good weldability are used in the aerospace industries. One of the most promising applications for vanadium-titanium and vanadium-titanium-chromium alloys is for projected use as fuel element cladding in liquid-metal-cooled fast breeder atomic reactors.

Compounds of vanadium are used in the chemical industry as catalysts in such processes as the production of sulphuric acid and the catalytic cracking of petroleum products. Other uses include applications in colouring of glass and ceramic glazes, as fixers and driers in paints, varnishes, dyes and inks and in processing of coloured film. Vanadium compounds are used in welding rod and other wear-resistant materials.

Minerals and occurrences

The more important of many known vanadium-bearing minerals are the complex sulphide, patronite, a vanadium-bearing mica, roscoelite, a potassium uranium vanadate, carnotite, the lead vanadates, vanadite, descloizite and mottramite. Patronite with asphaltite was an important source of vanadium at Mina Riga in the Peruvian Andes until 1955 when mining of the high-grade deposit was completed. Vanadates of lead, zinc and copper found in the oxidized zones of base-metal deposits have been sources of vanadium production in several countries. Vanadium-bearing titaniferous magnetites in South Africa, Finland and Norway have become important sources and similar deposits are known in the U.S.S.R., Canada and the United States. Vanadium occurs in some clays, shales and phosphate rocks and is found in association with asphaltum, coal, chromium, copper, iron, lead, titanium, uranium and petroleum.

Vanadium has not been produced commercially from deposits in Canada but many occurrences are known to occur in magnetite-ilmenite or ilmenite-hematite occurrences within anorthosite-gabbro igneous complexes. A typical analysis of ilmenite-hematite from Lac Tio, Lac-Allard area, Quebec, shows 0.34 per cent V_2O_5 and a representative sample of magnetite-ilmenite from the Lac Doré complex in the Chibougamau area, Quebec, shows 0.5 per cent V_2O_5. The Athabasca tar sands in northern Alberta contain an estimated 240 parts per million (0.024 per cent) of vanadium, part of which could be recovered from the coke residue of the distillation process. It is to be noted that the V_2O_5 content of the Highveld Steel and Vanadium Corporation's South African titaniferous magnetite ore ranges from 1.4 to 1.9 per cent in comparison with the analyses of the materials in Canada.

Prices

United States vanadium prices in U.S. currency published in Metals Week of December 28, 1970, and December 20, 1971

	December 28 1970	December 20 1971
	($)	($)
Vanadium pentoxide, per lb of V_2O_5, fob mine or mill		
98% fused	1.94	1.50 *(n)*
Air dried (technical)	2.02	2.21
Dealers (mainly export)	2.00	1.50
Ferrovanadium, per lb V, packed fob shipping point, freight equalized to nearest main producer		
Standard grade	4.12	4.12
Carvan	3.48	3.48
Dealers (mainly export)	4.50	*(n)*
Ferovan	..	3,68

*n*Nominal; .. Not available.

Tariffs

Canada

Item No.		British Preferential	Most Favoured Nation	General
			(%)	(%)
32900-1	Vanadium ores and concentrates	free	free	free
37520-1	Vanadium oxide	free	free	5
35101-1	Vanadium metal, ex-alloy	free	5	25
37506-1	Ferrovanadium	free	5	5

United States

Item No.		Effective on and After January 1 1970	1971	1972
		(%)	(%)	(%)
601.60	Vanadium ores and concentrates	free	free	free
632.58	Vanadium metal, unwrought, waste and scrap (duty on waste and scrap suspended to June 30, 1973)	7	6	5
632.68	Vanadium alloys, unwrought	10	9	7.5
633.00	Vanadium metal, wrought	12.5	10.5	9
607.70	Ferrovanadium	8.5	7	6
422.60	Vanadium pentoxide	22	19	16
422.58	Vanadium carbide	8.5	7	6
427.22	Vanadium salts	22	19	16
422.62	Other vanadium compounds	22	19	16

Sources: The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa. Tariff Schedules of the United States Annotated (1971), TC Publication 304.

Zinc

G. S. BARRY

Canadian recoverable zinc output in 1971 was 1,227,375 short tons, just slightly lower than in 1970. Canada remained the world's leading mine producer, accounting for 30 per cent of the total production of noncommunist countries. Production of refined zinc declined to 410,030 tons, from 460,663 tons produced in 1970. Output was at 77 per cent of the total rated capacity of the four primary zinc plants, partly because of a strike at one plant. Canadian zinc consumption in 1971 was 5.7 per cent higher than in 1970. Improvements were substantial in the consumption of galvanized and die-cast products.

Canadian exports of zinc in concentrates decreased by 2.9 per cent from 892,093 tons in 1970 to 866,273 tons in 1971, reflecting the worldwide decrease in demand that continued for most of 1971. Exports of refined zinc were also lower. Exports to the United States decreased by 14 per cent, with a very large decrease in the sale of concentrates, partly offset by an increase in the sales of metal. These changes reflect the growing need of the United States to import more refined zinc because seven plants are closing in the 1969-1973 period. United States smelter production decreased by 13 per cent in 1970 and by a further 12 per cent in 1971.

Canadian exports of zinc in concentrates to Japan increased from 149,217 tons in 1970 to 153,071 tons in 1971; to Belgium, they rose sharply from 188,895 tons in 1970 to 264,833 tons in 1971 to fill a demand created by increased smelting and refining capacity. Exports to West Germany and France were higher but these were offset by a significant drop in exports to the Netherlands.

Domestic production

Mine production. Table 2 gives information on the operations of the 38 mining companies that produced zinc-bearing ore on a regular basis during 1971. Of the 14 mines that produce over 20,000 tons of zinc in concentrates per year seven increased and seven decreased their 1971 output compared to 1970. Some of the largest mines, the Ecstall mine at Timmins, Ontario, the Faro mine, Yukon Territory, the Geco mine, Manitouwadge, Ontario, and Brunswick No. 6 and No. 12 mines and the Heath Steele mine in New Brunswick, posted increases. Sharp decreases were registered by mines that lost production because of strikes, namely, the Buchans mine in Newfoundland and the mines of Hudson Bay Mining and Smelting Co., Limited, in Manitoba.

Anvil Mining Corporation Limited, which opened the Faro 5,500-ton mill in the Yukon Territory in 1969, expanded its capacity to 6,600 tons in 1970 and to 7,800 tons per day early in 1972. The company ships zinc concentrates and lead concentrates to Japan. In addition, it began in 1971 to ship a bulk zinc-lead concentrate to Metallgesellschaft A.G. of West Germany, and during the year shipped 69,457 tons, averaging 46.08 per cent combined lead-zinc.

Sherritt Gordon Mines, Limited, which discovered the Ruttan copper-zinc orebody in 1969, continued development work on the property, and is scheduled to go into production in 1973. Construction of the 10,000-ton concentrator at the mine site and of the town of Leaf Rapids, 15 miles west of the mine, began during the year. Leaf Rapids is being designed and established with provincial government aid as a model northern community and will serve as a district centre rather than a mining town alone. Ruttan ore reserves at December 31, 1971 were 51,000,000 tons averaging 1.61 per cent zinc and 1.47 per cent copper, of which approximately 21 million tons will be mined by open pit. The open-pit ore will average more than 2.1 per cent zinc. Zinc concentrates will be sold to Japanese smelters; the copper concentrates are to be smelted and refined in Canada by Noranda Mines Limited, both

(text continued on page 12)

Table 1. Canada, zinc production, trade and consumption, 1970-71

	1970		1971p	
	(short tons)	($)	(short tons)	($)
Production				
All forms[1]				
Ontario	340,242	108,401,112	379,452	126,965,000
Quebec	205,030	65,322,624	190,059	63,594,000
Northwest Territories	238,558	76,004,563	185,146	61,950,000
New Brunswick	161,094	51,324,500	159,567	53,391,000
British Columbia	137,795	43,901,606	149,638	50,069,000
Yukon	77,983	24,845,216	114,651	38,362,000
Manitoba	39,463	12,572,970	25,150	8,415,000
Newfoundland	29,913	9,530,344	15,106	5,054,000
Saskatchewan	21,833	6,955,819	8,606	2,880,000
Nova Scotia	–	–	–	–
Total	1,251,911	398,858,754	1,227,375	410,680,000
Mine output[2]	1,381,300		1,400,168	
Refined[3]	460,663		410,030	
Exports				
Zinc, blocks, pigs, and slabs				
United States	121,308	33,097,642	158,302	41,246,000
Britain	95,149	24,297,234	64,978	16,867,000
India	28,859	6,369,065	16,545	3,541,000
West Germany	10,187	2,452,606	9,402	2,358,000
Brazil	5,690	1,235,794	9,267	1,917,000
Philippines	6,427	1,552,340	6,426	1,574,000
Venezuela	4,873	988,763	5,328	1,112,000
Hong Kong	3,576	910,665	3,022	771,000
Pakistan	5,933	1,197,297	3,845	769,000
Thailand	2,816	720,031	2,932	754,000
Netherlands	1,043	289,304	3,312	724,000
Italy	9,672	2,000,191	3,331	712,000
Japan	8,598	1,923,911	2,329	540,000
Sweden	4,626	1,203,157	1,665	470,000
Other countries	42,697	9,642,668	21,543	4,628,000
Total	351,454	87,880,668	312,227	77,983,000
Zinc contained in ores and concentrates				
Belgium and Luxembourg	188,845	27,319,848	264,833	42,499,000
United States	338,876	42,435,461	235,397	29,264,000
Japan	149,217	23,368,462	153,071	26,107,000
West Germany	35,102	5,563,090	60,108	9,294,000
France	37,860	5,716,429	46,601	8,409,000
Netherlands	84,217	12,635,622	38,889	5,875,000
Britain	29,300	3,206,852	26,724	3,405,000
India	13,799	2,009,935	13,526	1,828,000
Italy	5,211	742,720	11,022	1,634,000
Finland	–	–	6,534	1,235,000
Norway	9,616	1,281,460	8,364	1,064,000
Other countries	–	–	1,204	186,000
Total	892,043	124,279,879	866,273	130,800,000

Table 1 (cont'd)

	1970		1971p	
	(short tons)	($)	(short tons)	($)
Zinc and alloy scrap, dross and ash (gross weight)				
United States	3,449	627,375	2,107	452,000
Netherlands	1,367	150,039	1,442	155,000
Belgium and Luxembourg	993	109,363	1,710	118,000
Spain	–	–	253	53,000
Britain	357	61,052	210	25,000
South Korea	–	–	130	25,000
Other countries	1,235	136,720	80	3,000
Total	7,401	1,084,549	5,932	831,000
Zinc fabricated materials, nes				
United States	5,009	2,006,981	5,449	2,303,000
Venezuela	79	39,369	183	78,000
Britain	1,674	576,485	265	76,000
Belgium-Luxembourg	6	15,802	649	76,000
Italy	137	56,279	177	62,000
Other countries	1,015	319,216	214	41,000
Total	7,920	3,074,132	6,937	2,636,000
Imports				
In ores and concentrates	403	22,766	82	23,000
Dust and granules	711	301,806	1,329	565,000
Slabs, blocks, pigs and anodes	368	114,914	4,003	1,281,000
Bars, rods, plates, strip and sheet	634	434,271	511	312,000
Slugs, discs, shells	328	165,165	5	3,000
Zinc oxide	2,184	679,084	2,370	736,000
Zinc sulphate	1,658	200,414	1,399	182,000
Zinc fabricated material, nes	484	539,453	578	682,000
Total	6,770	2,457,873	10,277	3,784,000

	1970 Primary	1970 Secondary	1970 Total	1971p Primary	1971p Secondary	1971p Total
	(short tons)			(short tons)		
Consumption						
Zinc used for or in the manufacture of:						
Copper alloys (bronze, brass, etc.)	12,038	..	..	13,744	..	..
Galvanizing						
Electro	1,017	..	..	1,472	..	..
Hot-dip	52,648	..	..	54,073	..	..
Zinc die-cast alloy	17,469	..	..	18,822	..	..
Other products (including rolled and ribbon zinc, zinc oxide)	22,459	2,390	24,849	23,230	2,647	25,877
Total	105,641	2,723	108,364	111,341	2,993	114,334
Consumers stocks on hand at end of year	10,035	645	10,680	8,622	602	9,224

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.
pPreliminary; .. Not available for publication; – Nil; nes Not elsewhere specified.

Table 2. Principal zinc mines in Canada, 1971 and [1970]

Company and Location	Mill or Mine Capacity	Grade of Ore: Zinc	Lead	Copper	Silver	Ore Produced	Contained Zinc Produced	Remarks
	(tons ore/day)	(%)	(%)	(%)	(oz/ton)	(tons)	(tons)	
Newfoundland								
American Smelting and Refining Company, Buchans	1,250 [1,250]	12.39 [12.68]	6.90 [7.02]	1.08 [1.11]	3.71 [3.73]	173,000 [359,000]	19,366 [41,960]	Operations closed down by strike from June 21 to Nov. 1971
Nova Scotia								
Dresser Minerals, Division of Dresser Industries, Inc., Walton	140 [140]	0.5 [0.5]	3.3 [6.3]	0.36 [0.33]	4.35 [3.58]	16,125 [27,263]	49 [117]	Mine flooded Oct. 1970. Mill operated intermittently on stock-piled material in 1971
New Brunswick								
Anaconda American Brass Limited, New mines Division, Bathurst	850 [–]	1.90 [–]	– [–]	3.83 [–]	. . [–]	154,995 [–]	1,643 [–]	Production started Jan. 1971; operations suspended Nov. 7, 1971
Brunswick Mining and Smelting Corporation Limited, Bathurst No. 6 mine	3,500 [3,500]	5.76 [5.86]	. . [2.12]	0.36 [0.33]	. . [1.84]	1,300,946 [1,100,703]	67,590 [50,650]	No. 6 mill shut down in third quarter of 1971 to allow for conversion to produce separate zinc and lead concentrates. ISF smelter operations discontinued at end of year and converted to process lead concentrates only. Zinc concentrates will be exported
No. 12 mine	6,000 [6,000]	8.11 [7.54]	3.25 [2.93]	0.30 [0.32]	2.44 [2.19]	1,567,352 [1,519,981]	94,510 [82,424]	
Heath Steele Mines Limited, Newcastle	3,000 [3,000]	5.29 [5.40]	2.23 [2.26]	0.97 [0.97]	2.21 [2.20]	972,456 [1,030,899]	39,270 [37,870]	Mill capacity will be increased to 4,000 tpd in 1972-1975
Nigadoo River Mines Limited, Robertville	1,000 [1,000]	2.66 [2.63]	2.53 [2.63]	0.27 [0.32]	3.37 [3.59]	322,956 [319,689]	7,786 [6,847]	Mine and mill closed by strike, Nov. 21, 1971. Operations suspended Jan. 4, 1972
Quebec								
Bell Allard Mines Limited, Matagami	– [900]	– [9.26]	– [–]	– [0.58]	– [1.11]	– [61,265]	– [5,015]	Open-pit operation terminated Nov. 1970
Delbridge Mines Limited, Noranda	– [–]	8.62 [10.29]	– [–]	0.45 [0.71]	2.86 [3.48]	154,172 [196,844]	11,639 [17,889]	Ore milled at Quemont mill. Mining stopped in Sept. 1971

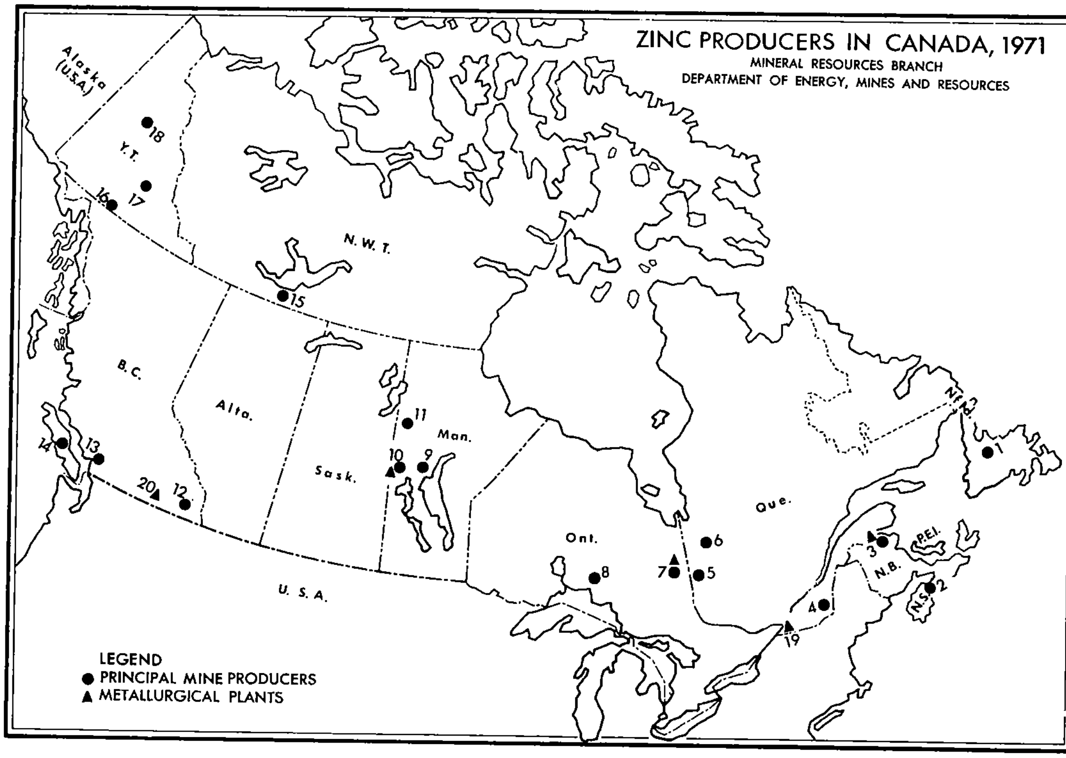
Falconbridge Copper Limited, Lake Dufault Division, Noranda Norbec and Millenbach mines	1,500 [1,300]	2.02 [1.82]	– [–]	1.48 [1.36]	0.60 [0.53]	509,095 [419,171]	7,285 [5,324]	Production started at Millenbach mine on Oct. 13, 1971, which will operate at approx. 1,100 tpd with Norbec supplying remainder. Milling is at Norbec mill
Kerr Addison Mines Limited, Normetal (Normetal Mine)	1,000 [1,000]	5.74 [6.72]	– [–]	1.76 [1.77]	1.50 [1.47]	335,298 [348,100]	16,397 [20,354]	Salvage basis; expected to close in 1973. In 1971 production included 4,132 tons of ore from Normetmar property
Manitou-Barvue Mines Limited, Val-d'Or	1,600 [1,600]	1.96 [2.19]	1.42 [0.36]	. . [0.59]	4.42 [4.66]	225,915 [362,170]	3,568 [5,007]	Mine closed temporarily Oct. 29, 1971. Mill processes Louvem's copper ore
Mattagami Lake Mines Limited, Matagami	3,850 [3,850]	9.3 [9.1]	– [–]	0.62 [0.59]	1.07 [0.86]	1,386,160 [1,430,864]	118,007 [119,247]	
New Hosco Mines Limited, Matagami	– [900]	– [0.76]	– [–]	– [0.94]	– [0.38]	– [64,248]	– [148]	Completed mining May 1970
Orchan Mines Limited, Matagami	2,000 [1,900]	10.66 [11.10]	– [–]	0.93 [1.03]	1.27 [1.36]	409,492 [414,520]	39,736 [42,411]	
Quemont Mines Limited, Noranda	2,400 [2,400]	2.06 [1.89]	– [–]	0.78 [0.78]	1.03 [0.91]	332,916 [299,636]	4,948 [3,957]	Milling and mining operations ceased Nov. 11, 1971. During 1949-71 period mine produced 280,300 tons of zinc
Sullivan Mining Group Ltd., Stratford Centre, (Cupra, D'Estrie and Weedon mines)	1,400 [1,400]	2.22 [2.95]	0.32 [0.57]	1.87 [1.78]	0.71 [1.14]	399,206 [375,447]	6,584 [8,554]	
Ontario								
Big Nama Creek Mines Limited, Manitouwadge	– [–]	5.12 [3.76]	0.06 [0.06]	0.81 [0.80]	1.07 [0.99]	41,717 [88,965]	. . [2,729]	Ore milled by Willroy Mines Limited. Mine closed in Sept. 1971
Canadian Jamieson Mines Limited, Timmins	550 [575]	2.14 [3.07]	– [–]	1.33 [1.77]	. . [. .]	20,567 [207,885]	297 [4,505]	Mining and milling terminated Feb. 12, 1971
Ecstall Mining Limited, Timmins	10,000 [9,000]	9.74 [. .]	.35 [. .]	1.38 [. .]	4.05 [. .]	3,673,350 [3,584,124]	317,520 [304,036]	Preparation for underground mining in progress; shaft to 3,050 ft completed in Aug. 1971. Electrolytic zinc plant under construction
Jameland Mines Limited, Timmins	– [–]	1.95 [0.28]	– [–]	1.29 [1.35]	. . [. .]	156,586 [191,810]	1,661 [. .]	Ore treated at Kam-Kotia mill

Table 2 (cont'd)

Company and Location	Mill or Mine Capacity	Grade of Ore: Zinc	Lead	Copper	Silver	Ore Produced	Contained Zinc Produced	Remarks
	(tons ore/day)	(%)	(%)	(%)	(oz/ton)	(tons)	(tons)	
Kam-Kotia Mines Limited, Timmins	2,500 [2,500]	2.51 [2.78]	– [–]	0.78 [0.78]	.. [..]	480,145 [650,869]	8,076 [9,338]	Milling reduced to 5-day week, effective May 1971, in line with the extractive capacity of remaining ore reserves
Noranda Mines Limited, Geco Division, Manitouwadge	5,000 [5,000]	5.52 [3.89]	.. [..]	2.27 [1.86]	2.03 [1.82]	1,759,952 [1,366,176]	80,000 [48,102]	
Selco Mining Corporation, Limited South Bay Division, Uchi Lake	500 [–]	13.29 [–]	– [–]	2.33 [–]	.. [–]	130,019 [–]	14,844 [–]	Mill tune-up started March 3, 1971; official opening of mine July 3, 1971
Willroy Mines Limited (incl. Willecho mine), Manitouwadge	1,600 [1,600]	3.33 [4.02]	0.13 [0.20]	0.89 [0.85]	1.36 [1.99]	427,589 [388,005]	11,707 [15,412]	Production from Big Nama Creek Mines Limited included for 1971
Manitoba and Saskatchewan								
Hudson Bay Mining and Smelting Co., Limited, Flin Flon and Snow Lake (Flin Flon, Schist Lake, Flexar, Chisel Lake, Stall Lake, Osborne Lake, Anderson Lake, Dickstone)	7,500 [7,500]	3.2 [3.9]	0.2 [0.2]	2.8 [2.7]	0.5 [0.6]	1,084,000 [1,709,000]	29,648 [67,429]	Flin Flon and Snow Lake operations closed down by strike from Jan. 27 to June 22, 1971. Central mill treats ore from all mines
Sherritt Gordon Mines, Limited, Lynn Lake, Fox mine	3,000 [3,000]	1.54 [1.13]	– [–]	2.86 [3.07]	.. [..]	1,022,000 [389,000]	5,659 [96]	In first full year of operation copper recoveries over 94% but zinc recoveries below expectations
British Columbia								
Anaconda American Brass Limited, Britannia Mines Division, Britannia Beach	3,000 [3,000]	.. [..]	– [–]	1.17 [..]	.. [..]	720,964 [320,642]	.. [127]	Zinc production not reported for 1971
Canadian Exploration, Limited, Salmo	– [1,900]	– [2.7]	– [1.2]	– [–]	– [..]	– [216,000]	– [5,100]	Jersey zinc-lead operations closed Aug. 1970

Cominco Ltd., Sullivan mine, Kimberley	10,000 [10,000]	. . [. .]	. . [. .]	. . [. .]	. . [. .]	2,005,301 [2,194,743]	102,015 [104,238]	
Bluebell mine, Riondel	700 [700]	. . [. .]	. . [. .]	. . [. .]	. . [. .]	256,797 [245,529]	12,961 [12,614]	Operations closed in Dec. 1971 due to ore depletion. In operation intermittently between 1895 and 1952 and continuously since 1952
Copperline Mines Ltd., Golden	700 [700]	. . [4.67]	. . [3.46]	– [–]	. . [4.62]	. . [36,228]	2,766 [1,381]	Operations closed in June 1971
Kam-Kotia-Burkam Joint Venture, Silmonac mine, Sandon	150 [150]	6.60 [6.79]	6.39 [7.58]	– [–]	17.99 [19.0]	39,154 [13,232]	2,438 [837]	
Reeves MacDonald Mines Limited, Remac Reeves mine	1,000 [1,200]	4.50 [4.75]	1.41 [1.56]	– [–]	. . [. .]	25,296 [107,312]	1,062 [4,716]	Mine closed and milling ceased in July 1971
Annex mine		8.63 [9.0]	0.89 [1.07]	– [–]	2.51 [3.3]	166,089 [70,714]	13,540 [6,029]	Milled at Reeves mill
Teck Corporation Limited, Beaverdell mine	110 [115]	0.80 [0.89]	0.70 [0.89]	– [–]	17.52 [13.37]	36,404 [33,225]	290 [296]	
Western Mines Limited, Buttle Lake, V.I.	750 [1,000]	6.9 [6.38]	0.7 [0.75]	2.0 [1.97]	1.6 [1.36]	386,541 [386,976]	22,901 [21,961]	Open-pit operations provided 50.5% of mill feed in 1971
Yukon Territory								
Anvil Mining Corporation Limited, Faro	7,700 [6,600]	6.74 [6.4]	4.92 [4.4]	– [–]	. . [. .]	2,673,000 [1,961,000]	136,419 [83,031]	Mill capacity increased in 1971
United Keno Hill Mines Limited, Elsa	550 [500]	5.19 [5.25]	5.17 [4.07]	– [–]	30.57 [27.30]	94,754 [93,215]	3,266 [3,733][r]	
Venus Mines Ltd., Carcross	300 [300]	. . [0.98]	. . [1.15]	– [–]	. . [5.30]	. . [23,796]	. . [124]	Production started Sept. 1970 and ceased in June 1971
Northwest Territories								
Pine Point Mines Limited, Pine Point	8,000 [8,000]	6.5 [7.1]	2.6 [3.0]	[–]	[. .]	3,891,927 [3,860,000]	239,369 [252,051]	Underground test stoping conducted in 1971

– Nil; . . Not available; [r]Revised.



Principal producers
(numbers refer to numbers on map)

1. American Smelting and Refining Company (Buchans Unit)
2. Dresser Minerals, Division of Dresser Industries, Inc.
3. Brunswick Mining and Smelting Corporation Limited
   Heath Steele Mines Limited
   Nigadoo River Mines Limited
4. Sullivan Mining Group Ltd.
5. Delbridge Mines Limited
   Falconbridge Copper Limited, Lake Dufault Division
   Manitou-Barvue Mines Limited
   Kerr Addison Mines Limited (Normental mine)
   Quemont Mines Limited
6. Mattagami Lake Mines Limited
   New Hosco Mines Limited
   Orchan Mines Limited
7. Canadian Jamieson Mines Limited
   Ecstall Mining Limited
   Kam-Kotia Mines Limited
8. Big Nama Creek Mines Limited
   Noranda Mines Limited (Geco mine)
   Willroy Mines Limited
9. Hudson Bay Mining and Smelting Co., Limited (Chisel Lake, Osborne Lake, Stall Lake, Dickstone)
10. Hudson Bay Mining and Smelting Co., Limited (Flexar, Flin Flon, Schist Lake)
11. Sherritt Gordon Mines, Limited (Fox Lake mine)
12. Copperline Mines Ltd.
    Cominco Ltd. (Sullivan, Bluebell mines)
    Tech Corporation Limited (Beaverdell mine)
    Reeves MacDonald Mines Limited (Reeve and Annex mines)
    Kam-Kotia-Burkam Joint Venture (Silmonac mine)
13. Anaconda American Brass Limited (Britannia mine)
14. Western Mines Limited
15. Pine Point Mines Limited
16. Venus Mines Ltd.
17. Anvil Mining Corporation Limited
18. United Keno Hill Mines Limited

Metallurgical plants

3. Brunswick Mining and Smelting Corporation Limited, Belledune
19. Canadian Electrolytic Zinc Limited, Valleyfield
10. Hudson Bay Mining and Smelting Co., Limited, Flin Flon
20. Cominco Ltd., Trail
7. Ecstall Mining Limited

Table 3. Prospective zinc-producing mines

Company and Location	Year Production Expected	Mill or Mine Capacity	Indicated Ore Reserves	Grade of Ore				Remarks
				Zinc	Lead	Copper	Silver	
		(tons ore /day)	(tons)	(%)	(%)	(%)	(%)	
Ontario								
Mattabi Mines Limited, Sturgeon Lake	1972	3,000	12,866,000	7.6	0.84	0.91	3.13	Jointly owned by Mattagami Lake Mines Limited and Abitibi Paper Company Ltd.
Manitoba								
Hudson Bay Mining and Smelting Co., Limited, Snow Lake area, Centennial mine	..	..	1,400,000	2.6	–	2.06	..	
Sherritt Gordon Mines, Limited, Ruttan mine, Lynn Lake district	1973	10,000	51,000,000	1.61	–	1.47	..	Open-pit operation planned

Table 4. Indicated zinc deposits under exploration

Company and Location	Indicated Ore Tonnage	Grade of Ore				Remarks
		Zinc	Lead	Copper	Silver	
	(tons)	(%)	(%)	(%)	(oz/ton)	
Newfoundland						
Newfoundland Zinc Mines Limited, Daniel's Harbour	5,400,000	7.70	. .	. .	. .	Exploration completed in 1970-71. Reserves include 3,700,000 tons of 8.5 per cent zinc
New Brunswick						
The Anaconda Company (Canada) Ltd., Bathurst, Caribou property	50,000,000	. .	. .	. .	. .	In temporary production January to November 1971. Feasibility studies continue on bringing this property into production
Chester Mines Limited, Newcastle	5,000,000	0.80	0.36	0.80	. .	Ore available for open-pit mining.
	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
Teck Corporation Limited, Portage Lakes area, Restigouche property	3,270,000	5.9	4.6	. .	2.50	
Ontario						
Sturgeon Lake Mines Limited, Sturgeon Lake	1,928,000	7.85	–	3.0	4.54	Optioned to Falconbridge Copper Mines Limited. Open-pit operation anticipated
Manitoba						
Stall Lake Mines Limited, Snow Lake	672,000	2.28	. .	5.38	. .	Falconbridge Nickel Mines 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

Yukon Territory						
Hudson Bay Mining and Smelting Co., Limited, Tom deposit, MacMillan Pass	8,645,000	8.4	8.1	–	2.75	Underground work through adit including diamond drilling in 1970 and 1971. Further development planned
Kerr Addison Mines Limited, Swim Lake deposit, Vangorda Creek	5,000,000	9.5 (Pb+Zn)		. .	1.50	
Vangorda Mines Limited, Vangorda Creek	9,400,000	4.96	3.18	0.27	1.76	Feasibility study made. No further exploration
Northwest Territories						
Arvik Mines Ltd., Little Cornwallis Island	. .	20.0 (Pb+Zn)		–	. .	Cominco Ltd. has a 75 per cent interest. The company states that "geological evidence suggests occurrences of a deposit of major size"
Buffalo River Exploration Limited, Pine Point	1,350,000	9.6	3.4	–	. .	Feasibility study for joint production with Coronet Mines Limited completed in 1971. Decision was made not to put the properties into production at present
Coronet Mines Ltd., Pine Point	1,372,735	10.2 (Pb+Zn)		–	. .	
Texas Gulf Sulphur Company, Strathcona Sound	7,000,000	16.0 (Pb+Zn)		–	. .	Underground exploration completed in 1970. Further work anticipated for 1972.

. . Not available; – Nil.

under 10-year contracts. By contrast, zinc concentrates from the company's Fox Lake mine, which started production in 1970, are shipped to Flin Flon for treatment, and copper concentrates to Japan.

The Sturgeon Lake area of northwestern Ontario will become a major centre of zinc production in Canada. The region now has three deposits and prospects are excellent for more discoveries. Mattabi Mines Limited, owned 60 per cent by Mattagami Lake Mines Limited, is scheduled for production for mid-1972 at an initial rate of 3,000 tons per day. The orebody contains 12,866,000 tons grading 7.60 per cent zinc, 0.91 per cent copper, 0.84 per cent lead and 3.13 ounces of silver per ton. Of this, approximately 8 million tons will be mined by open pit. Mattabi Mines Limited has three other deposits on its property containing a total of 2,831,000 tons of ore averaging 8.16 per cent zinc, 1.29 per cent copper, 0.88 per cent lead and 4.19 ounces of silver per ton, of which approximately 1 million tons is on a common boundary with Sturgeon Lake Mines Limited. The extension into Sturgeon Lake Mines ground contains 1,928,000 tons of open-pit ore grading 7.58 per cent zinc, 3.00 per cent copper and 4.59 ounces of silver per ton as reported by Falconbridge Copper Limited, which controls this property. Discussions on the possibility of joint production are taking place.

Falconbridge Copper Limited brought into production its Millenbach mine in October 1971, formerly a Lake Dufault Mines Limited property. Ore reserves are 2,675,000 tons averaging 3.6 per cent zinc and 3.5 per cent copper. The adjoining lower-grade Norbec mine will be operated on prolonged salvage basis supplying less than one third of the total tonnage for the mill, which was opened in 1964.

Selco Mining Corporation Limited, South Bay Division, brought into production its South Bay Mine in northwestern Ontario in July 1971, at 500 tons per day. Reserves at December 31, 1971 were reported at 581,639 tons grading 14.42 per cent zinc, 2.27 per cent copper and 3.75 ounces of silver per ton.

Mining and milling operations ceased on November 11, 1971 at Noranda's copper-zinc Quemont mine, a veteran operation that produced more than 280,000 tons of zinc since 1949. Other smaller zinc-producing

Table 5. Canada mine output, zinc, 1970-71

	1970	1971p
	(short tons)	
Newfoundland	36,743	17,715
Nova Scotia	117	33
New Brunswick	179,110	207,278
Quebec	227,459	207,057
Ontario	377,768	419,495
Manitoba-Saskatchewan	60,860	29,641
British Columbia	138,148	148,368
Yukon Territory	87,658	131,213
Northwest Territories	273,437	239,368
Total	1,381,300	1,400,168

Source: Statistics Canada. pPreliminary.

Table 6. Canada zinc production, exports and consumption, 1962-71

	Production		Exports			
	All Forms[1]	Refined[2]	In Ores and concentrates	Refined	Total	Consumption[3]
	(st)	(st)	(st)	(st)	(st)	(st)
1962	463,145	280,158	242,457	210,723	453,180	65,320
1963	473,722	284,021	213,044	200,002	413,046	73,653
1964	684,513	337,734	403,102	238,076	641,178	88,494
1965	822,035	358,498	487,445	264,200	751,645	93,796
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	426,728r	855,818	318,707	1,174,525	115,978
1969	1,207,625	466,357r	804,665	307,394	1,112,059	118,681
1970	1,251,911	460,663	892,043	351,454	1,243,497	105,641
1971p	1,227,375	410,030	866,273	312,227	1,178,500	111,341

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.
pPreliminary; rRevised.

mines that closed during 1971 are Canadian Jamieson Mines Limited, at Timmins, Big Nama Creek Mines Limited, at Manitouwadge, Delbridge Mines Limited, at Noranda, and Nigadoo River Mines Limited, at Robertville, New Brunswick (January 4, 1972). In British Columbia, Reeves MacDonald Mines Limited at Remac suspended mining at its Reeves mine but more than offset production losses by increasing output from its nearby Annex mine. Cominco Ltd. closed its Bluebell mine at Riondel because of ore depletion. This mine was an old lead-zinc producer, which was rehabilitated in 1952 and was in continuous production since that time.

Anaconda American Brass Limited began production from an open pit on the high-grade copper lense at its Caribou Mine, Bathurst, in January 1971. Because of concentrating difficulties, the mine was shut down in November 1971 and placed on a standby basis. Discussions are taking place concerning the possibility of bringing the entire large and low-grade body of complex copper-zinc-lead ore into production.

Tables 3 and 4 list zinc-bearing deposits in the exploration stage which may be in production in the foreseeable future.

Metal production. Production of refined zinc at the four Canadian plants in 1971 was as follows:

	Production Refined Zinc*	Rated Annual Capacity
	(short tons)	
Canadian Electrolytic Zinc Limited, Valleyfield, Quebec	119,600	140,000
Cominco Ltd., Trail, B.C.	211,000	263,000
Brunswick Mining and Smelting Corporation Limited, Belledune, N.B.	44,770**	54,000
Hudson Bay Mining and Smelting Co., Limited, Flin Flon, Man.	41,158	79,000

*From company annual reports. **Includes some ISF zinc sold.

Production of refined zinc in 1971 was at 77 per cent of rated capacity compared to 86 per cent in 1970. Canadian Electrolytic Zinc Limited treated concentrates from Quebec (Mattagami and Orchan) and from Ontario (Geco mine). Cominco's Trail plant, the largest in the world, was supplied by the company's Sullivan, Bluebell and Pine Point mines and by small custom shippers. Concentrates for the Hudson Bay Mining and Smelting Co., Limited plant came mainly from the company's central concentrator at Flin Flon serving several of the company mines and from purchased concentrates from other mines in Manitoba, the Northwest Territories and Ontario. The zinc refinery production was 47.6 per cent less than in 1970 because of a prolonged strike. Brunswick Mining and Smelting Corporation Limited (formerly East Coast Smelting and Chemical Company Limited) treated bulk zinc-lead concentrates from No. 6 and No. 12 mines in an Imperial Smelting Process (ISP) furnace and produced high-purity zinc in a redistillation plant at the same site and refined lead, silver and cadmium. The company decided to convert the ISP plant to a lead smelter at a cost of $10 million. A preliminary conversion was made in January 1972 with major changes to follow in November 1972 and mid-1973.

During 1971 Cominco Ltd. completed the modernization and expansion of its Trail zinc plant at a cost in excess of $20 million. Two new large fluid-bed roasters, each with capacity of 750 tons per day of contained zinc, were installed. One old 350-ton-per-day suspension roaster remained in operation. This in effect permitted an increase in the rated annual capacity of the refinery to approximately 300,000 tons.

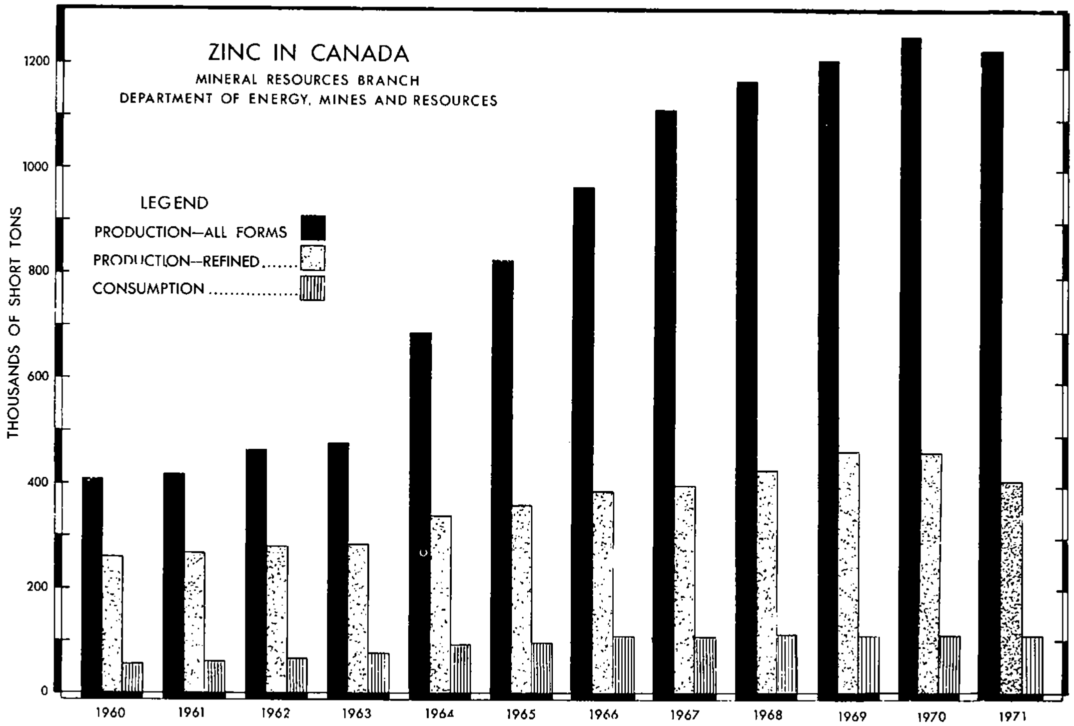
Ecstall Mining Limited, a wholly owned subsidiary of Texas Gulf Sulphur Company, continued to make good progress in 1971 on the construction of an electrolytic zinc plant near Timmins. The plant was opened in April 1972; it has an annual rated capacity of 120,000 tons of refined zinc, 1 million pounds of cadmium metal and 230,000 tons of sulphuric acid. Substantial quantities of silver and some copper and other metals will be recovered. The acid production was sold to a major Canadian firm under a 5-year contract. The plant and related facilities cost in excess of $75 million.

Metal consumption. Canadian zinc consumption increased above the low level registered in 1970 principally as a result of a general upturn in economic activity evident in the last quarter of 1971. The rise

Table 7. Canada, producers' domestic shipments of refined zinc, 1970-71

	1970	1971
	(short tons)	
1st Quarter	29,470	27,561
2nd Quarter	33,072	32,258
3rd Quarter	25,399	29,927
4th Quarter	29,350	32,418
Total	117,291	122,164

Source: Statistics Canada.



was mainly in the consumption of zinc in diecasting and alloys, reflecting the much better performance of the automobile and appliance industry.

World industry

Mine production. World mine production of zinc in 1971 decreased by 71,000 tons to 4,718,000 tons. Production in Canada, Peru and Japan increased, whereas most other countries recorded decreases. New mining projects now under completion could bring substantial increases in mining production in 1972 and 1973. This would be in keeping with a forecast of rapidly expanding demand. Some of the larger expected increases will be in Canada (the Mattabi mine in Ontario and the Ruttan mine in Manitoba); the United States (an expansion at the Balmat mine, New York and the Brushy Creek project in Missouri); Australia (the Roseberry mine); Peru (the new Morococha mine of Cerro de Pasco and expansion at Huanzala and Madrigal); Yugoslavia (expansion at Trepca); Nicaragua (new Neptune mine); and South Africa (the Prieska mine). Beyond 1973 the Greenex mine in Greenland, the Andaluza project in Spain, the Beltana project in Tasmania, Australia, the Zawra mine in India and the Tara project in Ireland are the more important developments foreseen.

Metal production. World metal production in 1971 totalled 4,133,000 tons, 5.4 per cent less than in 1970. Producers' stocks reached a high of 445,000 tons at the end of January 1971 and declined to 359,000 tons at year-end. Stocks further declined substantially to 283,000 tons by the end of April 1972. Zinc smelters generally curtailed production and operated at less than capacity for the greater part of 1971.

Production in the United States was 12 per cent lower because of relatively low demand (below 1968 and 1969 levels), and smelter closures. In Japan production rose by 5 per cent with all of the increase recorded in the fourth quarter. Canada recorded an 11 per cent drop in refined zinc production as compared to 1970 but also had a good fourth quarter which accounted for 27 per cent of the annual output. Of 23 countries reporting production to the International Lead and Zinc Study Group, 15 recorded decreases of metal production, the largest besides United States and Canada being Belgium, West Germany, Britain and Peru. Eight countries recorded increases, the largest by Japan and South Africa.

Several smelter operators closed or announced closures of uneconomic plants. American Zinc Company which temporarily shut its electrolytic plant

Table 8. World[1] mine production of zinc, 1970-71

	1969	1970	1971^p
	(st)	(st)	(st)
Canada	1,290,136	1,365,938	1,397,000
United States	607,814	586,980	540,683
Australia	507,614	492,512	462,529
Peru	347,228	362,660	368,171
Japan	296,962	308,316	327,386
Mexico	277,341	289,907	287,923
West Germany	147,710	151,788	164,023
Italy	146,387	122,026	115,301
Ireland	107,365	106,373	93,696
Republic of Zaire	105,822	114,640	. .
Sweden	94,137	98,106	105,491
Spain	89,067	105,050	93,255
Yugoslavia	83,886	85,980	97,885
Finland	78,044	69,115	56,107
Zambia	75,178	72,532	75,728
Other countries (mainly Morocco, South Africa, Argentina, Bolivia)	390,108	457,238	530,834
Total	4,644,799	4,789,161	4,716,012

Sources: International Lead & Zinc Study Group. For Canada, Statistics Canada.
[1]Total figures in respect to "other" countries exclude data relating to Bulgaria, China, Czechoslovakia, East Germany, Poland, Romania, North Korea and the U.S.S.R.
^{p}Preliminary; . . Not available.

Table 9. World[1] production of refined zinc, 1970-71

	1969	1970	1971^p
	(st)	(st)	(st)
United States	1,111,128	954,931	840,000
Japan	785,065	745,492	787,000
Canada	466,357	460,663	416,000
West Germany	306,442	332,016	281,000
Belgium	283,735	255,626	229,000
France	279,436	246,587	241,000
Australia	271,499	287,152	285,000
Britain	166,449	162,040	128,000
Italy	143,631	156,638	155,000
Mexico	91,712	88,956	92,000
Yugoslavia	89,278	67,351	54,000
Spain	88,405	96,342	99,000
Peru	70,548	76,059	59,000
Republic of Zaire	70,548	70,548	66,000
Other countries (mainly Finland, Netherlands, Norway)	265,657	371,479	407,000
Total	4,489,890	4,371,880	4,133,000

Sources: International Lead & Zinc Study Group.
[1]Total figures in respect to "other" countries exclude data relating to Bulgaria, China, Czechoslovakia, Eastern Germany, Poland, Romania, North Korea and the U.S.S.R.
^{p}Preliminary.

at East St. Louis, Illinois, in 1970 and then reopened it, closed it again in June 1971 and sold the plant to American Metal Climax, Inc. This company plans to rehabilitate and reopen this plant by 1974 to replace capacity lost by the announced closure in early 1974 of its Blackwell, Oklahoma, horizontal retort smelter (88,000 tons). The American Zinc Company also closed its Dumas plant, Texas (58,000 tons) in July 1971. Matthiessen & Hegeler Zinc Company closed its vertical retort plant at Meadowbrook, West Virginia, with an annual capacity of 40,000 tons, in May 1971. The New Jersey Zinc Company closed its vertical retort plant at Depue, Illinois (38,000 tons) in August 1971. All these retort plants had to be closed mainly for three reasons: low productivity, high energy costs and high costs of installing necessary new pollution abatement equipment. The timing of most closures also coincided with the general short-term slackening of economic activity in most western countries.

Imperial Smelting Corporation Limited closed its Imperial Smelting furnace (ISF) at Swansea, Wales in May 1971 (55,000 tons) and temporarily suspended operations at its plant at Avonmouth (100,000 tons) in August 1971 because of severe pollution problems. In Belgium the Prayon plant (55,000 tons) and the Overpelt plant (70,000 tons) will be replaced by new electrolytic plants in 1972 and 1974, and in Holland, the Budel plant (66,000 tons) will be replaced by a much larger electrolytic plant. Japan and West Germany also plan further similar phasing out of horizontal retort and thermal plants and their replacement by electrolytic facilities. As reported in the section on domestic events in Canada, the ISF plant in New Brunswick was converted to a lead smelter and Cominco modernized and expanded its Trail plant.

The accompanying table shows new and expanded smelter capacity planned up to 1975. Comparison with the data provided in the 1970 review indicates that construction or completion dates for eight facilities have been deferred by one or two years. As noted previously, the trend is towards establishing new capacity near industrial consuming centres. Not given

		Type and Location of New and Expanded Smelter Capacity	Increase in Capacity (tons per year)
1972	South Africa	Electrolytic (expansion), Vogelstuisbuilt	11,000
	West Germany	Electrolytic (new), Nordenham	88,000
	Belgium	Electrolytic (new), Ehein (replacing 55,000 at Prayon)	55,000
	Japan	Electrolytic (new), Iijima (replacing 21,000 at Dowa)	88,000
	Canada	Electrolytic (new), Timmins	120,000
1973	Italy	ISF (new), Portovesme	77,000
	Japan	Vertical Retort (expansion), Miike	15,000
	Japan	Electrolytic (expansion), Hikoshima	26,000
	Algeria	Electrolytic (new), Ghazaouet	44,000
	Mexico	Electrolytic (new), Torreon	115,000
	Netherlands	Electrolytic (new), Budel (replacing 66,000)	137,000
	Yugoslavia	ISF (new), Titow Veles	55,000
	West Germany	Electrolytic (further expansion), Nordenham	27,000
1974	Australia	Electrolytic (expansion), Risdon	22,000
	Japan	Electrolytic (expansion), Kamioka	12,000
	Italy	Electrolytic (expansion), Crotona	36,000
	Netherlands	Electrolytic (further expansion), Budel	55,000
	Japan	Electrolytic (further expansion), Iijima	46,000
	Belgium	Electrolytic (new), Overpelt (replacing 70,000)	88,000
1975	Peru	Electrolytic (new-first phase), Lima	80,000
	India	Electrolytic (expansion), Zawar	20,000
	India	Electrolytic (new), Vizag	33,000
	Mexico	Electrolytic (new), San Luis Potosi	110,000
	India	Electrolytic (expansion), Kerala	22,000

in the table are foreseen increases beyond 1975; these could include further expansions in Canada and Australia and possibly a new plant in Ireland.

Essentially, closures of uneconomic plants and deferment in new construction restored a balance between anticipated metal demand and production capacity, whereas not more than two years ago the forecast was for a large overcapacity in smelting and refining for the 1972-1975 period. By 1976, the electrolytic process facilities will represent approximately 70 per cent of total installed capacity compared with about 50 per cent over the last 10 years. This change arises mainly for economic reasons but also because the market increasingly requires higher-purity metal.

Consumption. World consumption of zinc in 1971 totalled 4,426,000 tons or 3.2 per cent more than in 1970. European consumption was about the same; all of the increase can be attributed to rises in demand in America, mainly the United States and Canada, and in Asia, mainly Japan. Of 24 countries that reported to the International Lead and Zinc Study Group, 12 reported increases and 12 decreases in consumption for the year. Significantly however, where quarterly data were available, 15 out of 21 reporting countries indicated better than average fourth-quarter consumption. This trend will continue into early 1972.

World trade. The major consuming areas in the world excluding countries with centrally planned economies are western Europe, the United States and Japan, which among them used 3.88 million tons of zinc in 1971 and accounted for 88 per cent of the total consumption. These areas produced only 1.66 million tons or 35 per cent of the world's mine output of zinc. This proportion declines annually. The remaining requirements, or approximately 2.2 million tons, were imported as either zinc concentrates or as refined metal, mainly zinc concentrates. The major consuming areas as defined above produced in 1971 3.02 million tons of refined metal, that is, 73 per cent of world production. This illustrates the fact that most of the world's smelting capacity is concentrated in industrialized areas where it must depend largely on imported concentrates. Canada, Australia, Peru and Mexico in that order are the largest exporters of zinc in concentrates and jointly accounted for approximately 83 per cent of world trade.

Outlook

Canadian mine output is expected to rise to 1,575,000 tons in 1972 and surpass 1,600,000 tons in 1973. By the end of 1972 Canadian rated smelter capacity will be approximately 645,000 tons with prospects of further additions in the 1973-75 period. It is expected that in 1972-73 the refineries will operate at better than 90 per cent of capacity and Canada will process approximately 40 per cent of its mine output. Domestic demand in 1972-73 will be strong, in pace with the general upturn of economic activity and as a result of continued growth in the alloy and galvanized products field and an upturn in die-casting, a sector that suffered very large decreases in 1970.

Zinc world demand, excepting countries with centrally planned economies, has grown at an average annual compound rate of 3.9 per cent from 1950 to 1971 inclusive. A growth rate of 4.5 per cent for 1972-1975 has been forecast at the March 1972 meeting of the International Zinc Institute in Montreal. By 1974 consumption should reach 5,260,000 tons. Substantial new mine production will be required to supply this demand. A review of world mine expansion plans and new prospects for production indicates that this demand can be met. A small part will be supplied by the release from the United States stockpile of 515,200 tons (over a minimum of four years) authorized on April 26, 1972. Canada should have no difficulties in marketing all the metal that it can produce above its domestic requirement.

New smelter projects under construction or planned around the world, in addition to present installations, ensure that smelter capacity will be adequate to meet the demand at efficient plant utilization. This balanced outlook, however, has the potential of changing into a tight metal supply situation if plant closures, other than those committed for, were to take place, or if a supply of some 100,000 tons of metal per year from eastern Europe was not to materialize.

Basic short-term trends in consumption are as follows: in the United States, stable usage in die-casting and growth in galvanizing, particularly in structural steel applications; in Europe, a steady demand for brass and rolled zinc, an important market there, and larger than normal growth in die-casting and increased usage of galvanized steel, which might be substantial, particularly in the automotive industry (at present only two European car models use galvanized sheet despite the increasing application of salt on roads in winter); in Japan consumption growth in die-casting should be the strongest, with steady growth in all other applications; in the rest of the world, growth should be above-average in all applications.

In terms of growth rates, forecast annual increases for the United States in 1972 and 1973 are between 4 and 4.5 per cent; for Europe a growth rate of better than 4 per cent is forecast for 1973 compared with only 2 per cent in 1972; in Japan growth rates for 1972 and 1973 should be, respectively, 6 per cent and 8 per cent. In the rest of the world an annual consumption growth of 6 per cent is forecast for 1973-74.

Beyond 1974-75 the above-average growth rates could only be maintained if the current strong uptrend in economic activity continues. Zinc consumption, however, could be moderated by slower replacement cycles in the production of cars, household appliances and other products, a trend that is now forecast not only because of changing consumer demands but for optimum resource utilization. Furthermore, demands for primary zinc could also be moderated by more emphasis on reclamation and recycling, a phase that at present is insignificant in the zinc industry.

Table 10. United States zinc consumption by end-use, 1970-71

	1970	1971p
	(short tons)	
Galvanizing	474,249	449,150
Brass products	127,747	146,641
Zinc-base alloy	463,636	498,926
Rolled zinc	41,065	34,966
Zinc oxide	43,829	40,037
Other uses	36,425	29,323
Estimated undistributed consumption	–	60,000
	1,186,951	1,259,043

Source: U.S. Bureau of Mines, Mineral Industry Surveys, Zinc Industry in December, 1971.
pPreliminary; – Nil.

Zinc uses

Zinc is used to galvanize steel and to make die castings, copper alloys, zinc sheet, and 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 in bridge construction to save on painting and maintenance costs. Wire, pipe and numerous other articles are galvanized where protection is required. In the automotive industry the usage of galvanized sheet has been relatively steady over the last eight years, averaging 160 to 170 pounds (using 11 to 12 lb of zinc) per vehicle, but has declined to approximately

110 to 120 pounds in the 1971 models. Consumption is expected to stabilize at this lower level or possibly at a slightly increased level because of the expanding availability of one-side galvanized sheet and consequently higher welding productivity.

Diecastings made of zinc-base alloys are used in the automotive industry for such parts as grilles, headlight and taillight assemblies, fender extensions, door and window hardware, carburettors and fuel pumps. The average automobile contains about 100 pounds of zinc in these parts. Zinc-base diecastings 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 diecastings 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 great promise is superplastic zinc alloy. It is a material containing 78 per cent zinc and 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 find use in pressed parts for the automobile and appliance industry.

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 as 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, is finding increasing use as the major constitutent of the paper coating for coated paper electrostatic copiers. 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.

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-base 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.

Research

Previously initiated zinc research activities on hot-dip galvanizing and zinc alloy development were continued through 1971 at the Mines Branch, Department of Energy, Mines and Resources.

Galvanizing. An exploratory study was completed on the effect of crystallographic orientation of the iron substrate on galvanized coating formation. Significantly higher than normal galvanizing reactivity was found on some low-index iron crystal orientations. The results were nevertheless inconclusive since, within this group, crystals of similar orientations, but of different origin, showed widely varying reactivity. A proposed extension of the investigation will concentrate on these anomalies in conjunction with examination of the effect of surface treatment parameters.

The phase of the project concerning galvanizing of iron-base binary alloys in a hydrogen atmosphere confirmed the pronounced increases in galvanizing reactivity induced by relatively low levels of silicon and phosphorus. Manganese showed negligible effects. The unexplained reversal in reactivity with increasing galvanizing temperatures which is exhibited at certain silicon levels was also better defined. Arrangements are being completed for a more comprehensive joint study with an outside laboratory to elucidate, and to find better methods of controlling, the high reactivity of silicon-containing steels.

Zinc alloy development. Research on the development of Zn-Al casting alloys, based on secondary zinc, attempts to understand the mode of action of deleterious impurities such as lead. A series of bimetallic couples of Zn-Al alloys with Pb, Sn, In, Zn and Al were exposed to corrosion in steam. The effects of preferential corrosion were very localized and were obscured by the effects of crevices formed between the components of the couples. Single-phase Zn-Al alloys (aluminum from about 0.01 to 0.1%) with and without small lead additions have been made up and corroded in steam in order to avoid the complicating effects of the second phase. Results have confirmed that intergranular corrosion occurs in the absence of the aluminum-rich phase and that it is accelerated by the presence of lead.

Prices

Canadian price of Prime Western zinc fob Toronto and Montreal, during 1971

	(¢/lb)
Jan. 1 to March 31	15
Apr. 1 to May 16	15.50
May 17 to July 26	16
July 27 to Dec. 31	17

The weighted average for the year was 16.12 cents per lb as compared to 15.32 cents in 1970. Effective March 6, 1972 Canadian producers raised the price to 18.0 cents per lb and on April 28 to 19.0 cents per lb.

The Canadian price used in the calculation of the value of Canada's zinc production was 16.73 cents per lb, which was equivalent to the high grade price.

United States price, Prime Western, delivered U.S.A.

	(¢/lb)
Jan. 1 to March 23	15
March 24 to May 12	15.50
May 13 to July 25	16
July 26 to Dec. 31	17

The average for the year was 16.14 cents per lb. The United States zinc industry initiated a new pricing practice on January 6, 1971, abandoning the fob East St. Louis base price in favour of a delivered quotation for all domestic sales.

Effective March 16, 1972 St. Joe Minerals Corporation raised its price of Prime Western zinc to 18.0 cents per lb, following a ruling by the Federal Price Commission. This created in the United States a period of price confusion with other major producers still quoting at 17.0 cents per lb, but effectively withdrawing sales offerings from the U.S. zinc market. By May 12, 1972, FPC granted approval for similar increases to all other companies.

The Producer Basis price used as a base for most sales outside North America was £127.950 per metric ton from the beginning of 1971 until June 17, when it was raised to £150.0 per metric ton.

The price in 1971 on the London Metal Exchange moved from a monthly average of £118.4 per metric ton during January 1971 to £142.1 during December 1971. The low average at £113.4 was recorded for February 1971. The average price for April 1972 was £151.3 per metric ton.

Tariffs

The following Canadian and United States tariffs apply for zinc in its various forms

Canada Item No.	British Preferential and Most Favoured Nation – all free	General
32900-1	Zinc in ores and concentrates	free
34505-1	Zinc spelter, zinc and zinc alloys containing not more than 10% by weight of other metal or metals, in the form of pigs, slabs, dust or granules/lb	2¢
34500-1	Zinc dross and zinc scrap for remelting, or for processing into zinc dust	10%
35800-1	Zinc anodes	10%

United States Item No.		(¢/lb)
602.20	Zinc ores and concentrates, on zinc content	0.67
	Unwrought zinc	
626.02	Other than alloys of zinc	0.7
626.10	Zinc waste and scrap	0.75
603.30	Zinc dross and skimmings	0.75
		(%)
626.04	Alloys of zinc	19
653.25	Zinc anodes	
	On and after Jan. 1, 1970	13
	1971	11
	1972	9.5

Sources: The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa. Tariff Schedules of the United States Annoted (1972) TC Publication 452.

The 10 per cent ad valorem import surcharge announced by President Nixon on August 15, 1971 had the effect of raising the duty, effective August 16, 1971, on imports of Canadian zinc metal from 0.7 to 1.75 cents a pound and on zinc in ores and concentrates from 0.67 to 1.67 cents a pound. On December 20, 1971, the President signed a proclamation rescinding immediately this 10 per cent surcharge on foreign imports.

Zirconium and Hafnium

D. D. BROWN

Canada does not produce zirconium- or hafnium-bearing minerals but has many minor occurrences of zircon (ZrO_2SiO_2), the principal mineral source of zirconium. Hafnium is always associated with zirconium in zircon.

Canada's imports of zirconium alloys were 212,168 pounds valued at $4.1 million in 1971 compared with 207,114 pounds valued at $3.7 million in 1970 and 208,695 pounds valued at $4.5 million in 1969. These imports are principally of material required for the installation of nuclear power reactors already undertaken in Canada. Zirconium alloyed with 2.5 per cent columbium (niobium) was chosen for the pressure tubes in Canadian power reactors.

Eldorado Nuclear Limited at Port Hope, Ontario, suspended zirconium production at its zirconium production plant during 1971. The plant produced zirconium ingot metal and alloy for pressure tubes and fuel-cladding tubes used in Canada's growing nuclear reactor power development. The unique process developed by Eldorado that bypasses the intermediate stage of making sponge metal in the process of producing zirconium ingot used zircon sand concentrates from Australia as raw material.

Zircon (ZrO_2SiO_2), the principal mineral source of zirconium, has its major commercial use in the form of zircon sand concentrates in the making of foundry sand moulds, and in the manufacture of refractories, ceramics and abrasives. Zircon is also used to produce zirconium metal, alloys and compounds. The metal is highly resistant to corrosion, has strength at high temperature, and a *low* absorption capacity (or high transparency) for thermal neutrons that makes it and its alloys of particular importance as tubing used for fuel-cladding, pressure tubes and structural material in thermal nuclear power reactors using natural uranium fuel.

Hafnium always occurs in small amounts with zirconium and is so similar chemically that it was not positively identified until 1922. It is recovered as a byproduct of reactor-grade zirconium, which must be free of hafnium. Its principal importance at present is for neutron control rods in nuclear reactors because of its *high* neutron absorption capacity. Zirconium allows relatively free passage of neutrons whereas hafnium acts as a control barrier.

Production and trade

Australia became the world's leading producer of zirconium minerals soon after the start of the mineral-sands industry on its east coast in 1934. Its position has been maintained, except in 1938 when production was very low and in 1942 when Brazil's output of baddeleyite (ZrO_2) exceeded Australian production of zircon. Australia's production of zircon concentrates in the first half of 1971 was 204,946 tons with a zircon content (ZrO_2SiO_2) of 202,103 tons. Preliminary figures, subject to revision, reported by the Bureau of Mineral Resources, Geology and Geophysics, Canberra, indicate production of 389,107 tons of zircon concentrates and exports of 380,448 tons in 1970. Japan imported 118,762 tons of zircon concentrates from Australia in 1970; the United States imported 82,528 tons.

The United States is the second largest producer of zircon and is the only substantial producer other than Australia. Zircon is recovered in the United States as a coproduct of dredging for heavy-mineral sands in Florida and Georgia. Production statistics are not published but United States consumption was 145,011 tons in 1970 and an estimated 150,000 tons in 1971. Imports of zircon concentrates, reported by the U.S. Bureau of Mines, were 94,759 tons in 1970 and an estimated 95,000 tons in1971.

The Phosphate Development Corporation, a government-controlled mining company, mines a copper-magnetite-apatite-baddeleyite ore at Phalaborwa in the Transvaal, Republic of South Africa. Baddeleyite has been recovered as a byproduct from mill tailings by gravity and magnetic separation.

Table 1. Canada, zirconium imports, 1970-71

	1970		1971^p	
	(pounds)	($)	(pounds)	($)
Imports				
Zirconium alloys				
United States	204,463	3,620,000	211,363	4,071,000
Sweden	2,161	41,000	805	12,000
France	195	3,000	–	–
Japan	193	2,000	–	–
Italy	102	1,000	–	–
Total	207,114	3,667,000	212,168	4,083,000
Consumption				
Ferrozirconium (gross weight)	44,000	. .	. .	. .

Source: Statistics Canada. ^{p}Preliminary; – Nil; . . Not available.

Products and uses

The principal use of zircon is in making steel and iron foundry sand moulds, mould facings and cores, and as milled flour for mould and core washes; it is used especially in steel foundry production of castings having exact specifications. Foundry consumption of zircon in the United States during 1971 was estimated at about 65 per cent of total domestic consumption of zircon sand concentrates. Silica sand, olivine and chromite are zircon's chief competitors in foundry use.

Zirconium is used for other refractory applications as zircon sand and as zirconia (ZrO_2) for the manufacture of bricks and refractory shapes and in the manufacture of ceramics. Consumption of zircon sands in refractories and in ceramics during 1971 was about 15 per cent and 12 per cent, respectively, of United States total domestic consumption. Milled zircon and zirconia are used as opacifiers in ceramic glazes and enamels, in electric insulators, pigments, abrasives and chemicals. The dioxide alone or mixed with other oxide carriers such as alumina, silica, magnesia, or clay is used as a catalyst in the production of gasoline and in the cracking stage of refining crude oils. Zirconium tetrachloride is the principal intermediate chemical compound used in the manufacture of other zirconium compounds.

Zirconium metal formed after the 1 to 5 per cent hafnium impurities occurring in zircon have been removed is called 'reactor grade' and is used in nuclear power reactors. The important properties of zirconium in this application are its low neutron cross section (0.18 barns), good mechanical strength, high heat conduction and corrosion resistance. A 500,000-kilowatt unit of the CANDU-PHW (pressurized heavy water) type of power reactor installed at Pickering, Ontario, requires approximately 55 tons of zirconium in the installation and will require 7.6 tons a year for replacement fuel rods.

Table 2. Australian zircon production, 1961-70

	Zircon Concentrate	Zircon (ZrO_2SiO_2 content)
	(st)	(st)
1961	152,859	150,642
1962	149,902	147,962
1963	207,010	203,965
1964	206,172	204,035
1965	254,087	251,612
1966	263,927	260,851
1967	317,724	313,962
1968	329,498	325,829
1969	$369,296^r$	$356,602^r$
1970^p	389,107	384,130

Source: Australian Mineral Industry, *Quarterly Review.* ^{r}Revised; ^{p}Preliminary.

Table 3. Australian exports of zircon concentrates, 1968-70^p

	1968	1969^r	1970^p
	(short tons)		
Japan	66,232	70,907	118,762
United States	64,340	74,255	82,528
France	28,455	23,507	30,656
Britain	44,552	34,679	25,951
Other countries	94,476	107,574	122,591
Total	298,055	310,922	380,488

Source: Australian Mineral Industry, *Quarterly Review.* ^{p}Preliminary; ^{r}Revised.

Table 4. World production of zircon concentrates, 1969-71 ^{p}

	1969	1970 ^{p}	1971 ^{e}
	(short tons)		
Australia	369,296 ^{r}	389,107	400,000
Brazil	3,874		
Malaysia	1,562		
Thailand	276		
Ceylon	75	(4,000)	(5,000)
United States	..		
Malagasy	..		
Total	375,083	393,107	405,000

Sources: Australian Mineral Industry, *Quarterly Review*; U.S. Bureau of Mines, *Minerals Yearbook, 1969*: U.S. Commodity Data Summaries, January 1972.

^{p}Preliminary; ^{e}Estimate; ^{r}Revised; .. Not available.

Hafnium, which is only recovered as a byproduct in the processing of zircon to reactor-grade zirconium, is used as a neutron control-rod material in nuclear power reactors. It is used in this application because of its high neutron absorption cross section (108 barns), which also makes necessary its removal from reactor-grade zirconium. Significant commercial use of hafnium outside the field of nuclear technology in 1971 included the hafnium in the nickel-base superalloy component parts for gas turbine aircraft engines and the high intensity photo-flash cube. Hafnium improves the creep, ductility and working life of turbine parts. Hafnium metal as a shredded foil provides a photo-flash bulb or cube that gives a 50 per cent increase in light intensity and a colour that eliminates the need for a blue filter. Other uses, developed or proposed, are as incandescent filaments, as a 'getter' in vacuum tubes to absorb traces of oxygen and nitrogen, as electrodes in X-ray tubes, in rectifiers, as a component of explosive detonating caps, as a surface coating on nickel and stainless steel by metallizing, and as a film for printed circuits.

Minerals and occurrences

Zirconium is widely distributed in nature and although not one of the most abundant elements it is estimated to form 0.22 per cent of the earth's crust and is more abundant than zinc, nickel, copper or lead. The most important zirconium mineral is the silicate, zircon (ZrO_2SiO_2). Because of its resistance to weathering, attrition and high specific gravity, it is found in beach deposits of heavy minerals in association with ilmenite, rutile and monazite. The oxide baddeleyite (ZrO_2), is the other important zirconium mineral; it is found in South Africa in the alkaline-carbonatite Phalaborwa complex. Zircon is theoretically 67.2 per cent ZrO_2 and 32.8 per cent SiO_2, but usually contains about 2 per cent hafnia (HfO_2). Baddeleyite is essentially pure zirconium oxide in crystalline form but usually contains about 1 per cent hafnia. Certain altered varieties of zircon, such as alvite and cyrtolite, contain hafnia in amounts varying from 5 per cent to over 10 per cent.

Zircon is an accessory mineral in igneous, sedimentary, and metamorphic rocks but is rarely found in mineable concentrations except where weathering and reconcentration have occurred. It is a typical minor constituent of pegmatites and nepheline syenites, occasionally appearing as local patches of crystalline zircon and cyrtolite. It usually occurs as shiny, stout, brown crystals with low pyramids at the terminations.

Patches several square feet in area containing zircon crystals from one-tenth inch to one inch in diameter have been found in Haliburton County, Ontario. Occurrences of scattered crystals of zircon and cyrtolite have been noted in Renfrew and Hastings counties and in Henry Township, Parry Sound district, Ontario. Rich zones of zircon crystals associated with titanite in a large body of pyroxenite are reported in Harrington Township, Argenteuil County, Quebec.

The most important sources of zircon are in natural concentrations of heavy minerals found in beach sands along the most easterly part of the Australian coast. Bulk concentrates made from Australian zircon-rutile-ilmenite sands range from 45 to 70 per cent zircon, 10 to 30 per cent rutile and 10 to 20 per cent ilmenite. Other constituents are monazite, garnet, cassiterite, tourmaline and spinel. Zircon-bearing sands are found in many other countries including India, Republic of South Africa, Ceylon, the U.S.S.R., Sierra Leone and the United States.

Mining and concentration of mineral sands

Natural concentrations of mineral-bearing sands are mined by dredging to recover zircon, rutile and ilmenite. The mining plant usually used on the east Australian shorelines consists of a floating dredge of the suction or bucket variety and a concentrating plant. The concentrating plant is floated on pontoons in the dredge pond for large plants but is usually land-based for small plants working on isolated deposits. Producers presently mine sands with a heavy mineral content as low as 0.5 per cent. A fully floating plant described by Associated Minerals Consolidated Limited (AMA) has a capacity of 1,500 tons an hour. A small plant may have a capacity as low as 40 tons an hour and is built in sections, each on skids, so they can be moved on tractors. The mined material is fed into a wet-concentrating plant immediately behind or adjacent to each mining dredge, where the bulk of silica sand is removed and immediately returned to the mined-out area. A large floating plant, operating on an average feed grade of 1.9 per cent heavy mineral averaged 92.1 per cent recovery over a period of 10 months. Mining recovery was 85.3 per cent after allowing for mineral left in topsoil and on the pond bottom. Primary concentrates, assaying from 80 to 95 per cent heavy mineral, are trucked to a final product-separation plant for electrostatic and magnetic concentration and cleaning of the different mineral products to high-grade bulk and packaged concentrates. The products recovered by AMA are standard zircon, premium zircon, zircon flour, ilmenite, rutile and monazite. The zircon products contain a minimum of 66 per cent ZrO_2; zircon flour is zircon ground to flour form in the range of 200 to 400 mesh.

Outlook

The production of zircon is a component of the mineral sands industry and has more than doubled during the past decade. Zircon prices have remained stable in recent years because of their coproduct and byproduct nature; the availability of zircon from mineral sands is a function of the demand for rutile and ilmenite as well as zircon and the prevailing market price of each mineral concentrate. It is unlikely that there will be any shortage of zircon concentrates for several years but in the long term Australian production of zircon is expected to level off since rutile-zircon producers will find it increasingly difficult to expand production from lower-grade sands and environmental factors may force cutbacks in some of the more attractive eastern beach areas.

Zirconium and hafnium metal markets will increase to keep pace with the needs of commercial nuclear power reactors. The demand for zircon sand for foundries is expected to increase.

Prices

	Dec. 1970 and Dec. 1971
	($ U.S.)
Zircon ore[1]	
sand, per long ton, cif U.S. ports, bags, 65% ZrO_2,	70
Camden, N.J., bulk, 60% ZrO_2, per short ton	66.50-68
Starke, Fla., domestic, bags	56-57
Zirconium[1]	
per pound, fob shipping point, sponge, powder, platelets, low hafnium	7-14
commercial	5-10
Hafnium[2]	
sponge, per pound	75
rolled bar, plate, per pound	120

Sources: [1]*Metals Week*; [2]*American Metal Market.*

Tariffs

Canada

Item No.		British Preferential	Most Favoured Nation	General
			(%)	(%)
34720-1	Sponge and sponge briquettes, ingots, blooms, slabs, billets and castings in the rough, of zirconium or zirconium or zirconium alloys for use in Canadian manufacture (expires 31st January 1973)	free	free	25
34730-1	Bars, rods, sheet, strip, wire, forgings, castings and tubes, seamless or welded, of zirconium or zirconium alloys for use in the manufacture of nuclear power reactors, including fuel components (expires 31st January 1972)	free	free	25
33508-1	Zirconium oxide (effective 1 Jan. 1969)	free	5	15
92845-4	Zirconium silicate (effective 1 Jan. 1969)	free	free	free

United States

Item No.		Effective on and after January 1 1970	1971	1972
		(%)	(%)	(%)
601.63	Zirconium ore (including zirconium sand)	free	free	free
629.60	Zirconium metal, unwrought, other than alloys, waste and scrap (duty on waste and scrap suspended on or before 30 June 1973)	8.5	7	6
629.62	Zirconium, unwrought alloys	10	9	7.5
629.65	Zirconium metal, wrought	12.5	10.5	9
422.80	Zirconium oxide	7	6	5
422.82	Other zirconium compounds	7	6	5

Sources: The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa, Tariff Schedules of the United States Annotated (1972), TC Publication 352.

Statistical Tables

GENERAL REVIEW STATISTICAL SUPPLEMENT

The statistics presented in the statistical supplement are chiefly derived from Statistics Canada sources. Certain information is obtained from other departments and from recognized international statistical sources.

The purpose of the supplement is to present in a comprehensive manner statistical data pertaining to Canada's mining and mineral industries. This is done within a framework of ten sections, each composed of a number of tables. An attempt is made to present all relevant general statistics which are of importance in understanding the role of the mining and mineral industries in the Canadian economy. Information relating to specific mineral commodities or segments of the mineral industry is found not in the supplement but in separate mineral commodity analyses within this volume.

Section 1 Production

This section of 12 tables covers various aspects of mineral production. In Table 1 are found production statistics in terms of quantities and values, for some 60 individual minerals. This is an historical series, dating back to 1886, and relates to minerals produced from Canadian resources. Recoveries from secondary materials and imported ores and concentrates are not included.

The endeavour, in the computation of the quantities and values of the minerals recorded in this table, is to measure the components as close to the producing operation as feasible. In the case of nonmetallic minerals, quantities shipped plus values fob mine or mill, as reported by the producer, are taken as production. Mine shipments, with company stated values, are also taken to reflect production in the case of certain metals. The computation of quantity and value production statistics, however, for some metals is more complicated. Some metallic ores and concentrates produced in Canada's mines are treated at smelting and refining operations in Canada. The quantities of metals obtained from the processing of these materials are recorded and valued using average metal prices. However, some ores and concentrates are not treated in Canada but are shipped to foreign smelters for processing. In cases of this nature, the metal contents are computed, and from these quantities certain deductions for smelter and refinery losses are made in order to obtain recoverable metal contents. Average unit metal prices are then used in conjunction with recoverable metal calculations to arrive at production values.

Tables 1 to 7 include the breakdown of mineral production component data, but none is on the Standard Industrial Classification (SIC) or Standard Commodity Classification (SCC) basis. Table 11 is a series showing physical volume indexes of the mining industry. The indexes are computed in a manner that permits a reflection of changes in volume without the distorting influence of price factors. These indexes are compiled on the Standard Industrial Classification basis, and are presented in the table unadjusted for seasonal variation and on the base year 1961 being equal to 100. Table 8 shows Canada's position in the world as a producer of important minerals. Statistics for Canada are production data from Statistics Canada and are contained in Table 1 of this section. World totals and individual country totals, other than for Canada, are obtained from recognized international mineral publications, such as the American Bureau of Metal Statistics, and United States Bureau of Mines. Tables 9 and 10 report values added on the Standard Industrial Classification basis. The value added concept enables meaningful inter-industry comparisons, since duplicating cost factors, such as cost of materials used, fuel and electricity, are removed.

Section 2 Trade

This section of seven tables covers Canada's trade in minerals and mineral products. These data are extracted from the publications of the External Trade Division of Statistics Canada. The values of exports and imports of crude minerals essentially

This Statistical Supplement was prepared by B.F. Burke and Staff, Statistics Section, Mineral Resource Branch.

refer to mine products. Mineral products consist of products of varying degrees of the manufacturing process, from primary refinery products to more advanced products of rolling mills and other processing establishments. This class of mineral products includes fully fabricated products which are used in the construction or fabrication of more advanced end-use products. Fully fabricated end-use products of a mineral origin, such as machines composed of ferrous or nonferrous metals, are not included under the class of fabricated products reported in this section. The values are based on information appearing on customs import and export entries. Export entries define the value of imports as the actual amount received or to be received in terms of Canadian dollars, exclusive of all charges such as freight, insurance and handling. Generally this definition gives values, fob point of consignment. The requirement under the Canadian Customs Act generally is for the evaluation of goods, fob point of shipment in the country of export.

Section 3 Consumption

In this section, composed of three tables, an attempt is made to relate Canadian consumption of the main crude minerals to domestic production of these minerals. The relationship of consumption as a per cent of production facilitates the determination of surpluses and shortages in the mineral commodities covered. Consumption data in Tables 20 and 21 are summations of quantities reported to Statistics Canada on special annual mineral consumption surveys. The production totals are those reported in Table 1 of Section 1. Table 21 shows, for certain minerals, the relationship between apparent consumption and production. Reported consumption for these minerals is not readily available. Therefore, apparent consumption which consists of an arithmetical calculation of production plus imports less exports, with no adjustments for stocks, indicates Canadian consumption requirements for these minerals. Table 22 gives annual production and consumption of certain important nonferrous refined metals. Consumption of these metals is reported by consumers to Statistics Canada through special consumption surveys. Production of refined metals includes metal derived from all sources, including that from domestic ores and concentrates, from imported ores and concentrates and from secondary materials. Refined production of the metals in this table is reported in the respective commodity sections.

Section 4 Prices

This section comprises four statistical tables. Annual average price data shown in Table 23 are, with the exception of gold, obtained from *Metals Week* and are in United States currency.

The gold price, in Canadian currency, is the average annual Royal Canadian Mint buying price. The wholesale price indexes, reported in Tables 24 and 25 are compiled from the Prices Division of Statistics Canada. Wholesale price indexes (base 1935-39-100) of specific mineral products are shown in Table 24, while an historical series of wholesale price indexes for overall groups of mineral products and nonmineral products is shown in Table 25. Table 26 reports industry selling price indexes. These indexes differ from those of Tables 24 and 25 in that they measure the selling price levels of products within an industry.

Section 5 Principal Statistics

Tables 27 to 34 outline principal statistics in the mining and smelting and refining industries. In Table 27 statistics relating to production and related works, costs of fuel and electricity and materials and supplies are given by types of mining. Gross values of production, together with net values or values added of production, are shown. The values added totals are gross values with certain cost factors, such as costs of fuel and electricity, and cost of materials and supplies, removed. The mineral manufacturing industries are covered in Table 28, which includes the same statistical coverage as in Table 27. The values added totals for the mining industry are reported in Table 11. Tables 31 to 34 report component detail on the consumption of fuel and electricity by the mining and mineral manufacturing industries.

Section 6 Labour, Labour Costs, Wage Rates

Tables 35 and 36 of this section show employment and salaries and wage data for the mining industry. Table 38 reports employment data for wage earners only. These employment figures are included in the overall totals of Tables 35 and 36. Table 39 shows productivity information in respect to tons mined per worker and wage cost per ton mined for certain types of metal mining.

In Table 40 man-hours paid per ton mined in metal and industrial mineral operations are presented for a number of years. These are calculated totals, with the basic statistics being obtained from relevant Statistics Canada reports, and also, where necessary, from mining schedules received by SC. The wage rates shown in Table 41 are obtained from mining operators by the Department of Labour and reported in the publication "Wage Rates, Salaries and Hours of Labour". The index numbers of average wage rates reported in Table 42 are also obtained from this source. Average weekly wages and hours of hourly rated employees shown in Tables 43 and 44 are obtained from SC monthly and annual publications on man-hours and average earnings by industries. Information contained in Tables 45 and 46 on industrial fatalities and strikes and lockouts, by industries, is obtained from *Labour Gazette* a publication of the federal Department of Labour.

Section 7 Mining, Exploration, Drilling

In this section, operations of the mines are brought into perspective by showing tonnages of ore mined and rock quarried by types of mining operations. Amounts expended in mining exploration and development by province are shown in Tables 49 and 50. These amounts are reported by provinces and this reflects where both exploration and development funds are being expended. Table 51 reports, in footages by main types of mineral deposits, diamond drilling carried out both by drilling contractors and by mining companies with their own equipment. From 1964 those mining companies that are not yet in production have been excluded from the tabulation. Exploration diamond drilling only by producing companies and by contractors is reported in Table 52, and drilling other than exploration is covered in Table 53. Data in these tables are included in the totals of Table 51. Table 54 covers operations of diamond drilling contractors only. The footages reported here represent total drilling by the contractors in mining operations and, to some extent, in nonmining operations. Contract drilling for oil and gas by type of drilling and also gross income and employment are reported in Table 55. Data for the tables in this section are obtained from the SC mining publications and, in some cases, from basic schedules. The SC report "Contract Drilling for the Mining Industry" is the basis of statistical data presented on contract drilling.

Section 8 Transportation

In this section an endeavour has been made to emphasize the role that minerals and mineral products have in various types of transportation. For example, in Tables 56 and 57 the tonnages of crude mineral products moved by Canadian railways are shown, while Table 58 shows the importance of fabricated mineral products in total railway revenue freight. Crude minerals transported through Canadian canals, in relation to total freight moved, are shown in Table 59. Tables in this section were derived from published data of the Transportation and Public Utilities Division of Statistics Canada.

Section 9 Taxation

Tables 61 and 62 report the taxes paid by the main sectors of the mining industry to the three levels of government, federal, provincial and municipal. These data are extracted from the published mining industry reports of Statistics Canada and also, where necessary, from annual census of mines schedules. Data in Table 62, reporting taxes paid by mining and mineral fabricating companies were extracted from "Corporation Taxation Statistics" a publication of the Corporations and Labour Unions Return Division of Statistics Canada. Taxes shown in Table 62 will not necessarily agree with those of Tables 60 and 61, chiefly because of differences in coverage and interpretation. Amounts shown in Tables 60 and 61 refer to actual payments made, while those of 62 are expressions of taxation levies.

Section 10 Investment, Finance

Tables 64 to 66 of this section are various breakdowns on capital and repair expenditures of the mining and mineral fabricating industries.

Capital invested on new construction and machinery and amounts expended on repair of existing structures and machinery are reported for the mining and mineral fabricating industries. These data are extracted from the Statistics Canada publication "Private and Public Investment in Canada". Information shown in Table 67 refers to investment in all aspects of the oil and gas industries and is from a special tabulation prepared in the Business Finance Division of Statistics Canada. Table 68 pertains to the degree of nonresident ownership of the mining industry in Canada, and is prepared from data appearing in the publication entitled, "Corporations and Labour Unions Returns Act, Part 1", published by the Corporation and Labour Unions Return Division of Statistics Canada. Financial statistics contained in Table 69, are derived from data published in "Corporation Financial Statistics" of the Statistics Canada. The statistics outlined in Table 70 on ownership and control have been prepared from data contained in balance of payments publications of Statistics Canada.

STATISTICAL TABLES

Table No. Title and Page

SECTION 1 PRODUCTION

		1950	1951	1952	1953	1954	1955	1956	1957	1958
Gross National Product-current prices	$ millions	17,995	21,640[r]	24,588[r]	25,833[r]	25,918[r]	28,528[r]	32,058[r]	33,513[r]	34,777[r]
Gross National Product-1961 prices	"	23,809	25,673[r]	27,968[r]	29,408[r]	29,047[r]	31,788[r]	34,474[r]	35,283[r]	36,098[r]
Value of manufacturing Industry shipments	"	..	..	..	..	..	19,513	21,637	22,178	22,171
Value of mineral production	"	1,045	1,245	1,285	1,336	1,488	1,795	2,085	2,190	2,101
Merchandise exports	"	3,104	3,897	4,282	4,097	3,860	4,258	4,760	4,789	4,791
Merchandise imports	"	3,125	4,005	3,916	4,248	3,967	4,568	5,547	5,473	5,050
Balance of trade Current account	"	−316	+517	+151	+443	+432	+698	+1,366	+1,455	+1,131
Corporation profits before taxes	"	2,506	2,800	2,640	2,611	2,290	2,965	3,345	3,056	3,075
Capital investment, current prices	"	3,862	4,424	5,424	5,968	5,802	6,531	8,196	8,813	8,488
Capital investment, 1961 prices	"	5,029	5,047	6,073	6,682	6,458	7,068	8,439	8,944	8,634
Population	000's	13,712	14,009	14,459	14,845	15,287	15,698	16,081	16,610	17,080
Labour force	"	5,163	5,223	5,324	5,397	5,493	5,610	5,782	6,008	6,137
Employed	"	4,976	5,097	5,169	5,235	5,243	5,364	5,585	5,731	5,706
Unemployed	"	186	126	155	162	250	245	197	278	432
Unemployment rate	%	3.6	2.4	2.9	3.0	4.6	4.4	3.4	4.6	7.0
Employment index	1961=100	86.1	92.3	94.7	96.2	93.2	95.4	101.9	100.0	100.4
Labour income	$ millions	8,629	10,103	11,208	12,110	12,432	13,215	14,719	15,825	16,180
Index industrial production	1961=100	57.3	6.72	65.3	70.1	70.0	77.7	85.8	87.2	86.7
Index manufacturing production	"	63.4	68.9	71.5	76.6	74.9	82.2	89.9	89.7	88.0
Index mining production	"	38.7	43.6	46.5	50.6	56.1	66.4	77.1	84.6	86.0
Index real domestic product	"	62.4	67.3	72.5	75.5	74.3	82.1	89.1	89.5	91.0
General wholesale price index	1935-39=100	211.2	240.2	226.0	220.7	217.0	218.9	225.6	227.4	227.8
Consumer price index	1961=100	79.6	88.0	90.2	89.4	89.9	90.1	91.4	94.3	96.8

.. Not available; [p]Preliminary; [r]Revised.

Indicators, 1950-1971

1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971[p]
36,846[r]	38,359[r]	39,646[r]	42,927[r]	45,978[r]	50,280[r]	55,364[r]	61,828[r]	66,409[r]	72,586[r]	79,749[r]	85,449[r]	93,094
37,470[r]	38,553[r]	39,646[r]	42,349[r]	44,531[r]	47,519[r]	50,685[r]	54,207[r]	56,016[r]	59,292[r]	62,363[r]	63,941[r]	67,449[r]
23,353	23,444	24,428	26,713	28,741	31,560	33,889	37,303	38,955	41,997	45,110[r]	45,991	49,243
2,409	2,493	2,603	2,881[r]	3,027	3,365	3,715	3,981	4,381[r]	4,722	4,736	5,713	5,924
5,022	5,256	5,755	6,179	6,799	8,094	8,525	10,071	11,112	13,251[r]	14,890[r]	16,820	17,744
5,509	5,482	5,769	6,258	6,558	7,487	8,633	9,866	11,075	12,358	14,130	13,952	15,607
+1,504	−1,243	−982	−830	−521	−424	−1,130	−1,162	−499	−107	−952[r]	+1,060	+262
3,504	3,359	3,427	3,819	4,188	4,819	5,199	5,145	5,020	6,142[r]	6,527[r]	5,943	6,822
8,500	8,328	8,292	8,769	9,398	10,980	12,935	15,088	15,348	15,455	16,927	17,798	19,788
8,568	8,281	8,292	8,632	9,020	10,253	11,515	12,820	12,993	12,880	13,560	13,840	14,692
17,483	17,870	18,238	18,583	18,931	19,290	19,644	20,015	20,405	20,744	21,061	21,377	21,681
6,242	6,411	6,521	6,615	6,748	6,933	7,141	7,420	7,694	7,919	8,162	8,374	8,631
5,870	5,965	6,055	6,225	6,375	6,609	6,862	7,152	7,379	7,537	7,780	7,879	8,079
372	446	466	390	374	324	280	267	315	382	382	495	552
6.0	7.0	7.1	5.9	5.5	4.7	3.9	3.6	4.1	4.8	4.7	5.9	6.4
102.2	100.7	100.0	102.2	104.4	108.2	114.3	120.7	122.6	122.7	126.9	127.1	127.5
18,309	19,303	20,136	21,597	23,057	25,219	28,181	31,907	35,275	38,493	43,203	47,036	51,712
94.2	96.2	100.0	108.3	115.2	126.6	137.0	146.0	150.8	161.1[r]	168.7[r]	172.3	177.6
94.5	96.1	100.0	109.0	116.2	127.4	138.8	148.7	152.3	162.5[r]	171.0[r]	169.5	173.5
97.3	97.4	100.0	106.2	112.1	126.0	131.9	134.2	142.1	152.4[r]	150.8[r]	174.8	182.5
95.7	98.0	100.0	106.9	112.7	120.4	129.0	138.0	142.4	149.8[r]	156.6[r]	160.4	167.6
230.6	230.9	233.3	240.0	244.6	245.4	250.3	259.5	264.1	269.9	282.4	286.4	289.9
97.9	99.1	100.0	101.2	103.0	104.8	107.4	111.4	115.4	120.1	125.5	129.7	133.4

Table 1. Canada Value of Mineral Production, Per Capita Values of Mineral Production and Population, 1931-1971

	Metallics	Industrial Minerals	Fuels	Total	Per Capita Value of Mineral Production	Population of Canada
	($ million)	($ million)	($ million)	($ million)	($)	(000)
1931	121	55	54	230	22.21	10,376
1932	112	30	49	191	18.20	10,510
1933	147	27	48	222	20.85	10,633
1934	194	30	54	278	25.91	10,741
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	11,654
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	214.69	20,405
1968	2,493	886	1,343	4,722	227.64	20,744
1969	2,378	893	1,465	4,736	224.87	21,061
1970	3,073	922	1,718	5,713	267.25	21,377
1971[p]	2,938	977	2,009	5,924	273.22	21,681

[p]Preliminary.

Table 2. Mineral Production[1] of Canada, 1970 and 1971, and Average, 1967-1971

		1970		1971p		Average 1967-1971	
		(quantity)	($000)	(quantity)	($000)	(quantity)	($000)
Metals	(000)						
Antimony	lb	726	1,104	330	249	861	630
Bismuth	″	590	3,371	267	1,331	550	2,322
Cadmium	″	4,308	15,336	4,132	7,889	4,701	13,882
Calcium	″	444	374	304	282	541	519
Cobalt	″	4,561	10,207	4,992	10,936	4,088	8,807
Columbium (Cb_2O_5)	″	4,694	4,820	2,176	2,199	2,925	2,926
Copper	st	673	779,242	715	754,517	641	662,514
Gold	troy oz	2,409	88,057	2,243	79,268	2,585	95,884
Iron ore	lt	46,709	588,631	43,281	559,779	41,179	521,060
Iron remelt	st	..	31,591	..	30,917	..	25,952
Lead	″	389	123,138	407	109,803	355	102,017
Magnesium	lb	20,707	7,141	14,504	5,205	17,046	6,289
Molybdenum	″	33,772	57,141	28,324	47,140	27,118	46,577
Nickel	st	306	830,167	294	798,162	265	620,152
Platinum group	troy oz	482	43,557	468	38,928	429	38,847
Selenium	lb	663	5,705	718	6,531	668	4,452
Silver	troy oz	44,251	81,864	44,938	70,103	42,810	80,599
Tantalum	lb	317	2,251	450	3,150	299	2,113
Tellurium	″	58	366	24	148	58	370
Thorium	″	–	–	–	–	95	177
Tin	″	264	422	294	512	285	505
Tungsten[2]	″	3,727	..	5,009	..	3,330	..
Uranium[3]	″	8,209	..	8,200	..	7,799	..
Yttrium	″	..	..	..	..	..	..
Zinc	st	1,252	398,859	1,227	410,680	1,191	365,286
Total metals		..	3,073,344	..	2,937,150	..	2,601,880
Nonmetals							
Arsenious oxide	lb	141	15	–	–	481	37
Asbestos	st	1,662	208,147	1,641	210,435	1,592	192,787
Barite	″	147	1,388	137	1,170	147	1,355
Diatomite	st	..	..	..	..	..	..
Feldspar	st	11	291	10	302	11	276
Fluorspar	st	..	4,596	..	2,550	..	2,977
Gemstones	lb	129	145	75	100	62	87
Grindstone	st	–	–	..	1	–	–
Gypsum	st	6,319	14,199	6,800	15,043	6,119	13,482
Iron oxide	st	–	–	–	–	–	–
Lithia	lb	–	–	–	–	–	–
Magnesite, dolomite and brucite	st	..	3,332	..	3,000	..	3,221
Mica	st	–	–	–	–	–	–
Nepheline	st	487	5,801	500	6,000	463	5,445
Peat moss	st	320	10,168	326	10,401	310	9,359
Potash (K_2O)	st	3,420	108,695	3,872	128,067	3,217	87,732
Pyrite pyrophyllite	st	363	1,699	318	1,186	350	1,819
Quartz	st	3,238	6,811	2,526	4,655	2,646	5,796
Salt	st	5,359	36,098	5,578	38,605	5,091	32,817
Soapstone, talc, pyrophyllite	st	72	1,142	67	1,110	71	1,066
Sodium sulphate	st	491	7,602	480	7,640	475	7,347

Table 2. (Cont'd)

		1970		1971p		Average 1967-1971	
		(quantity)	($000)	(quantity)	($000)	(quantity)	($000)
Nonmetals (Cont'd)							
Sulphur in smelter gas	st	706	7,433	676	5,106	663	7,318
Sulphur, elemental	st	3,548	28,353	3,065	20,771	2,933	51,686
Titanium dioxide, etc.	st	..	34,623	..	38,765	..	31,101
Total nonmetals		..	480,538	..	494,907	..	455,708
Fuels							
Coal	st	16,604	86,067	19,351	131,721	13,751	75,767
Natural gas	mcf	2,277,109	315,100	2,500,751	347,555	1,984,841	269,764
Natural gas byproducts	bbl	79,783	160,110	88,362	202,503	68,968	148,005
Petroleum, crude	"	461,180	1,156,454	492,568	1,327,425	419,104	1,060,483
Total fuels		..	1,717,731	..	2,009,204	..	1,554,019
Structural materials							
Clay products	$	..	42,661	..	46,825	..	46,746
Cement	st	7,946	156,193	9,534	194,218	8,338	160,772
Lime	st	1,648	21,075	1,519	19,050	1,536	18,681
Sand and gravel	st	202,656	133,558	201,450	134,250	205,226	133,233
Stone	st	65,323	87,976	64,800	88,100	71,509	92,758
Total structural materials		..	441,463	..	482,443	..	452,190
Total all minerals		..	5,713,076	..	5,923,704	..	5,063,797

.. Not available or not applicable; – Nil; pPreliminary.

Notes: [1] Data for indium, mercury, helium and nitrogen are not available for publication. [2] Production data for tungsten (quantities only) are available for publication for 1970 and 1971 only. [3] Up to and including 1969 production data for uranium, quantities and values, were available for publication. For 1970 and 1971 quantities only are available for publication.

Table 3. Canada Value of Mineral Production by Provinces and Mineral Classes, 1971P

	Metals		Industrial Minerals		Fuels		Total	
	($000)	(% of total)	($000)	(% of total)	($000)	(% of total)	($000)	(% of total)
Alberta	–	–	64,945	6.6	1,592,828	79.3	1,657,773	28.0
Ontario	1,308,657	44.6	246,009	25.2	8,695	0.4	1,563,361	26.4
Quebec	448,897	15.3	322,119	33.0	26	–	771,042	13.0
British Columbia	309,628	10.5	77,460	7.9	148,252	7.4	535,340	9.0
Saskatchewan	12,285	0.4	150,141	15.4	216,267	10.7	378,693	6.4
Newfoundland	309,344	10.5	27,371	2.8	–	–	336,715	5.7
Manitoba	278,799	9.5	26,719	2.7	14,092	0.7	319,610	5.4
New Brunswick	91,641	3.1	11,546	1.2	4,242	0.2	107,429	1.8
Northwest Territories	98,132	3.3	–	–	1,395	0.1	99,527	1.7
Yukon	80,131	2.7	13,900	1.4	–	–	94,031	1.6
Nova Scotia	215	0.1	36,490	3.7	23,407	1.2	60,112	1.0
Prince Edward Island	–		650	0.1	–	–	650	–
Total	2,937,729	100.0	977,350	100.0	2,009,204	100.0	5,924,283	100.0

PPreliminary; – Nil.

Table 4. Canada, Production of Leading Minerals by

		Nfld.	P.E.I.	N.S.	N.B.	Quebec	Ontario
Petroleum	bbl	–	–	–	10,000	–	958,000
	$	–	–	–	13,000	–	2,597,000
Nickel	st	–	–	–	–	798	217,594
	$	–	–	–	–	2,153,000	588,821,000
Copper	st	12,875	–	17	9,958	187,062	303,631
	$	13,596,000	–	17,000	10,516,000	197,537,000	320,634,000
Iron ore	st	22,600,000	–	–	–	12,661,000	11,289,000
	$	287,261,000	–	–	–	112,754,000	142,828,000
Zinc	st	15,106	–	–	159,567	190,059	379,452
	$	5,054,000	–	–	53,391,000	63,594,000	126,965,000
Natural gas	mcf	–	–	–	105,000	170,000	16,047,000
	$	–	–	–	59,000	26,000	6,098,000
Asbestos	st	77,000	–	–	–	1,333,000	44,000
	$	14,000,000	–	–	–	158,595,000	5,440,000
Cement	st	..	–	..	..	2,671,000	3,683,000
	$	2,478,000	–	4,818,000	3,811,000	47,277,000	72,187,000
Sand and gravel	st	6,100,000	850,000	7,700,000	4,700,000	37,000,000	84,500,000
	$	6,000,000	650,000	7,000,000	1,500,000	17,500,000	55,500,000
Coal	st	–	–	1,966,000	517,000	–	–
	$	–	–	23,407,000	4,170,000	–	–
Potash (K_2O)	st	–	–	–	–	–	–
	$	–	–	–	–	–	–
Lead	st	9,768	–	415	71,390	608	9,215
	$	2,637,000	–	112,000	19,275,000	164,000	2,488,000
Stone	st	100,000	–	900,000	1,300,000	30,200,000	27,500,000
	$	100,000	–	1,800,000	2,600,000	38,800,000	35,300,000
Gold	oz	4,000	–	–	5,000	651,000	1,122,000
	$	141,000	–	–	177,000	23,006,000	39,651,000
Silver	oz	420,000	–	55,000	5,011,000	5,642,000	17,575,000
	$	655,000	–	86,000	7,817,000	8,802,000	27,417,000
Molybdenum	lb	–	–	–	–	1,065,000	–
	$	–	–	–	–	1,890,000	–
Clay products	$	–	–	1,765,000	660,000	6,890,000	28,775,000
Platinum metals	oz	–	–	–	–	–	468,000
	$	–	–	–	–	–	38,928,000
Titanium dioxide	st	–	–	–	–	..	–
	$	–	–	–	–	38,765,000	–
Salt	st	–	–	889,000	–	–	4,172,000
	$	–	–	9,201,000	–	–	23,029,000
Sulphur elemental	st	–	–	–	–	–	3,000
	$	–	–	–	–	–	22,000
Lime	st	–	–	–	–	293,000	1,080,000
	$	–	–	–	–	3,500,000	12,825,000
Gypsum	st	600,000	–	4,932,000	80,000	–	715,000
	$	1,710,000	–	10,688,000	173,000	–	1,227,000
Cadmium	lb	–	–	–	135,000	137,000	2,567,000
	$	–	–	–	262,000	237,000	4,882,000
Uranium	lb	–	–	–	–	–	7,000,000
	$						..
Total, leading minerals	$	333,632,000	650,000	58,895,000	104,423,000	721,490,000	1,535,614,000
Total, all minerals	$	336,715,000	650,000	60,112,000	107,429,000	771,042,000	1,563,361,000
Leading minerals as % of all minerals		99.1	100.0	98.0	97.2	93.6	98.2

[p]Preliminary; – Nil; . . Not available.

Provinces and Territories, 1971[p]

Manitoba	Sask.	Alberta	B.C.	Y.T.	N.W.T.	Total Canada
5,604,000	88,445,000	371,339,000	25,268,000	–	944,000	492,568,000
14,092,000	198,118,000	1,050,889,000	60,442,000	–	1,274,000	1,327,425,000
74,151	–	–	1,404	–	–	293,947
203,326,000	–	–	3,862,000	–	–	798,162,000
56,464	7,690	–	134,110	2,550	150	714,507
59,625,000	8,121,000	–	141,620,000	2,693,000	158,000	754,517,000
–	–	–	1,925,000	–	–	48,475,000
–	–	–	16,936,000	–	–	559,779,000
25,150	8,607	–	149,638	114,651	185,146	1,227,376
8,415,000	2,880,000	–	50,069,000	38,362,000	38,362,000	410,680,000
–	69,830,000	2,070,468,000	343,842,000	–	299,000	2,500,751,000
–	9,078,000	294,007,000	38,166,000	–	121,000	347,555,000
–	–	–	88,000	99,000	–	1,641,000
–	–	–	18,500,000	13,900,000	–	210,435,000
516,000	191,000	1,004,000	957,000	–	–	9,534,000
12,384,000	6,207,000	22,088,000	22,968,000	–	–	194,218,000
14,000,000	8,200,000	16,400,000	22,000,000	–	–	201,450,000
9,000,000	4,000,000	13,300,000	19,800,000	–	–	134,250,000
–	3,300,000	8,931,000	4,637,000	–	–	19,351,000
–	6,377,000	51,499,000	46,268,000	–	–	131,721,000
–	3,872,000	–	–	–	–	3,872,000
–	128,067,000	–	–	–	–	128,067,000
175	–	–	123,635	108,092	83,387	406,685
47,000	–	–	33,381,000	29,185,000	22,514,000	109,803,000
1,100,000	–	200,000	3,500,000	–	–	64,800,000
2,500,000	–	700,000	6,300,000	–	–	88,100,000
31,000	23,000	–	84,000	17,000	306,000	2,243,000
1,096,000	813,000	–	2,969,000	601,000	10,814,000	79,268,000
714,000	220,000	–	7,738,000	5,852,000	1,711,000	44,938,000
1,114,000	343,000	–	12,071,000	9,129,000	2,669,000	70,103,000
–	–	–	27,259,000	–	–	28,324,000
–	–	–	45,250,000	–	–	47,140,000
345,000	990,000	3,350,000	4,050,000	–	–	46,825,000
–	–	–	–	–	–	468,000
–	–	–	–	–	–	38,928,000
–	–	–	–	–	–	..
–	–	–	–	–	–	38,765,000
27,000	228,000	262,000	–	–	–	5,578,000
166,000	3,990,000	2,219,000	–	–	–	38,605,000
5,000	20,000	2,963,000	74,000	–	–	3,065,000
36,000	232,000	19,977,000	504,000	–	–	20,771,000
51,000	–	95,000	–	–	–	1,519,000
900,000	–	1,825,000	–	–	–	19,050,000
133,000	–	–	340,000	–	–	6,800,000
298,000	–	–	947,000	–	–	15,043,000
81,000	27,000	–	1,088,000	83,000	14,000	4,132,000
157,000	52,000	–	2,111,000	161,000	27,000	7,889,000
–	1,125,000	–	–	–	–	8,200,000
	..					..
313,501,000	369,268,000	1,459,854,000	526,214,000	94,031,000	99,527,000	5,617,099,000
319,610,000	378,693,000	1,657,773,000	535,340,000	94,031,000	99,527,000	5,924,283,000
98.1	97.5	88.1	98.3	100.0	100.0	94.8

Table 5. Canada, Percentage Contribution of Leading Minerals to Total Value of Mineral Production, 1962-1971

	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971^p
Petroleum	20.9^r	20.9	20.0	19.4	19.8	19.8	19.9^r	21.4	20.2	22.5
Nickel	13.3^r	11.9	11.2	11.6	9.5	10.6	11.1	10.2	14.5	13.5
Copper	9.8^r	9.3	9.6	10.3	11.4	13.3	12.8	12.4	13.6	12.8
Iron ore	9.1^r	10.3	12.0	11.1	10.8	10.7	11.2	9.6	10.3	9.5
Zinc	3.9	4.0	5.7	6.7	7.3	7.3	6.9	7.8	7.0	7.0
Natural gas	3.6	4.1	4.3	4.3	4.4	4.5	4.8^r	5.5	5.5	5.9
Asbestos	4.5	4.5	4.3	3.9	4.1	3.7	4.0	4.1	3.6	3.6
Cement	3.9	3.9	3.8	3.8	3.9	3.3	3.1	3.4	2.7	3.3
Sand and gravel	4.1	4.1	3.7	3.6	3.8	3.3	2.7	2.6	2.3	2.3
Potash (K_2O)	0.1	0.7	0.9	1.5	1.6	1.5	1.8	1.5	1.9	2.2
Coal	2.4	2.4	2.2	2.1	2.1	1.3	1.1	1.1	1.5	2.2
Lead	1.5	1.5	1.6	2.4	2.3	2.0	1.9	2.0	2.2	1.9
Stone	2.4	2.6	2.5	2.6	2.7	2.3	2.0	1.9	1.5	1.5
Gold	5.4^r	5.0	4.3	3.6	3.1	2.5	2.1	2.0	1.5	1.3
Silver	1.2	1.4	1.2	1.2	1.2	1.4	2.2	1.8	1.4	1.2
Molybdenum	0.04	0.04	0.06	0.5	0.9	0.9	0.8	1.1	1.0	0.8
Uranium (U_3O_8)	5.5	4.5	2.5	1.7	1.4	1.2	1.1	1.1	. .	. .
Clay products	1.3	1.3	1.2	1.2	1.1	1.0	1.0	1.1	0.7	0.8
Platinum metals	1.0	0.7	0.8	0.9	0.8	0.8	0.9	0.7	0.8	0.7
Titanium dioxide	0.4	0.5	0.6	0.6	0.6	0.5	0.6	0.6	0.6	0.7
Salt	0.8	0.7	0.7	0.6	0.6	0.6	0.7	0.6	0.6	0.7
Sulphur, elemental	0.3	0.4	0.6	0.7	1.0	1.6	1.7	1.3	0.5	0.4
Lime	0.6	0.6	0.6	0.5	0.5	0.4	0.4	0.4	0.4	0.3
Gypsum	0.3	0.4	0.3	0.3	0.3	0.3	0.3	0.3	0.2	0.3
Cadmium	0.2	0.2	0.3	0.1	0.2	0.3	0.3	0.4	0.3	0.1
Other minerals	3.5^r	4.1	5.1	4.8	4.6^r	4.9	4.6^r	5.1	5.2	4.5
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

^{p}Preliminary; – Nil; . . Not available; ^{r}Revised.

Table 6. Canada, Value of Mineral Production by Provinces and Territories, 1962-1971

	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971^p
					($ million)					
Alberta	596^r	644	709	762	849	974	1,092	1,205	1,395	1,658
Ontario	913	874	904	994	958	1,195	1,356	1,223	1,590	1,563
Quebec	519	541	685	716	771	741	725	717	801	771
British Columbia	234	260	269	280	331	380	389	434	490	535
Saskatchewan	242	274	293	329	349	362	357	345	379	379
Newfoundland	102	138	182	208	244	266	310	257	353	337
Manitoba	159	170	174	182	179	185	210	246	332	320
New Brunswick	22	29	49	83	90	90	88	95	104	107
Northwest Territories	18	15	18	77	111	118	116	119	134	99
Yukon	13	14	15	13	12	15	21	35	77	94
Nova Scotia	62^r	67	66	71	86	53	57	59	57	60
Prince Edward Island	1	1	1	–	1	2^r	1	1	1	1
Total	2,881^r	3,027	3,365	3,715	3,981	4,381^r	4,722	4,736	5,713	5,924

^{p}Preliminary; – Nil; ^{r}Revised.

Table 7. Canada, Percentage Contribution of Provinces to Total Value of Mineral Production, 1962-1971

	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971[p]
Alberta	20.7[r]	21.3	21.1	20.5	21.3	22.2	23.1	25.4	24.4	28.0
Ontario	31.7[r]	28.9	26.9	26.8	24.1	27.3	28.7	25.8	27.8	26.4
Quebec	18.0[r]	17.9	20.3	19.3	19.4	16.9	15.4	15.2	14.0	13.0
British Columbia	8.1[r]	8.6	8.0	7.5	8.3	8.7	8.2	9.2	8.6	9.0
Saskatchewan	8.4[r]	9.0	8.7	8.9	8.7	8.3	7.6	7.3	6.6	6.4
Newfoundland	3.5[r]	4.6	5.4	5.6	6.1	6.1	6.6	5.4	6.2	5.7
Manitoba	5.5	5.6	5.2	4.9	4.5	4.2	4.4	5.2	5.8	5.4
New Brunswick	0.8	0.9	1.4	2.2	2.3	2.1	1.9	2.0	1.8	1.8
Northwest Territories	0.6	0.5	0.5	2.1	2.8	2.7	2.4	2.5	2.4	1.7
Yukon	0.5	0.5	0.5	0.3	0.3	0.3	0.5	0.7	1.4	1.6
Nova Scotia	2.2	2.2	2.0	1.9	2.2	1.2	1.2	1.3	1.0	1.0
Prince Edward Island	0.02	0.03	0.02	0.02	0.02	0.04	0.02	0.02	0.02	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)	1970	st	685,585
Zinc (mine production)	1970	st	5,832,377
Asbestos	1970	st	3,824,527
Silver	1969	000 troy oz	290,203
Potash K_2O (equivalent)	1969	000 st	18,657
Uranium (U_3O_8 concentrates) (excludes communist countries)	1969	st	21,261
Molybdenum (excludes communist countries)	1969	st	71,080
Elemental sulphur	1969	000 st	22,004
Gypsum	1970	000 st	55,457
Titanium concentrate (ilmenite)	1969	st	3,530,745
Aluminum (primary metal)	1970	st	10,979,015
Platinum group metals (mine production)	1970	troy oz	4,237,150
Gold (mine production)	1970	troy oz	47,426,173
Cadmium (smelter production)	1970	000 lb	37,682
Lead (mine production)	1970	st	3,783,149
Iron ore	1970	000 lt	742,989
Magnesium	1970	st	245,600
Copper (mine production)	1970	st	6,929,496

Important Minerals, 1970

Rank of Six Leading Countries and Production, with % of World Total					
1	2	3	4	5	6
Canada	Rep. S. Africa	U.S.S.R.	New Caledonia	Cuba	Australia
305,881	121,739	121,000	116,120	38,800	32,870
44.6	17.8	17.6	16.9	5.7	4.8
Canada	U.S.S.R.	U.S.A.	Australia	Peru	Japan
1,365,938	615,000	534,136	533,731	329,738	308,290
23.4	10.5	9.2	9.2	5.7	5.3
Canada	U.S.S.R.	Rep. S. Africa	China	Italy	U.S.A.
1,661,644	1,150,000	316,882	190,000	130,747	125,314
43.4	30.1	8.3	5.0	3.4	3.3
Canada	Mexico	U.S.A.	U.S.S.R.	Peru	Australia
43,531	42,904	41,906	37,000	34,147	24,667
15.0	14.8	14.4	12.7	11.8	8.5
U.S.S.R.	**Canada**	W. Germany	U.S.A.	E. Germany	France
3,505	3,492	2,853	2,804	2,535	2,134
18.8	18.7	15.3	15.0	13.6	11.44
U.S.A.	**Canada**	Rep. S. Africa	Australia	Portugal	Sweden
10,934	3,854	3,610	330	105	77
51.4	18.1	17.0	1.6	0.5	0.4
U.S.A.	**Canada**	Chile	Norway	Japan	Peru
49,903	14,825	5,337	330	296	185
70.2	20.9	7.5	0.5	0.4	0.3
U.S.A.	**Canada**	Mexico	France	U.S.S.R.	Japan
9,588	2,974	1,892	1,869	1,763	382
43.6	13.5	8.6	8.5	8.0	1.7
U.S.A.	France	**Canada**	U.S.S.R.	Britain	Spain
9,436	6,711	6,319	5,181	4,713	4,409
17.0	12.1	11.4	9.3	8.5	8.0
U.S.A.	Australia	**Canada**	Norway	Finland	Malaysia
931,247	785,065	749,281	540,903	152,339	143,300
26.4	22.2	21.2	15.3	4.3	4.1
U.S.A.	U.S.S.R.	**Canada**	Japan	Norway	France
3,976,148	1,600,000	1,071,718	807,800	584,403	420,027
36.2	14.6	9.8	7.4	5.3	3.8
U.S.S.R.	Rep. S. Africa	**Canada**	Colombia	U.S.A.	Japan
2,200,000	1,500,000	482,428	26,358	17,385	7,906
51.9	35.4	11.4	0.6	0.4	0.2
Rep. S. Africa	U.S.S.R.	**Canada**	U.S.A.	Ghana	Australia
32,164,107	6,500,000	2,408,574	1,743,322	703,858	617,000
67.8	13.7	5.1	3.7	1.5	1.3
U.S.A.	Japan	U.S.S.R.	**Canada**	W. Germany	Belgium
9,465	5,313	5,200	4,307	2,080	1,990
25.1	14.1	13.8	11.4	5.5	5.3
U.S.S.R.	U.S.A.	Australia	**Canada**	Mexico	Peru
585,000	571,767	488,898	394,548	194,663	172,808
15.5	15.1	12.9	10.4	5.1	4.6
U.S.S.R.	U.S.A.	France	**Canada**	Australia	China
191,921	89,791	56,499	46,709	45,175	42,321
25.8	12.1	7.6	6.3	6.1	5.7
U.S.A.	U.S.S.R.	Norway	Japan	**Canada**	Italy
112,007	55,000	38,959	11,394	10,354	8,355
46.6	22.4	15.9	4.6	4.2	3.4
U.S.A.	U.S.S.R.	Zambia	Chile	**Canada**	Zaire
1,719,700	990,000	758,382	755,700	672,717	424,893
24.8	14.3	10.9	10.9	9.7	6.1

Table 9. Canada, Census Value Added, Commodity-Producing Industries, 1964-1969

	1964	1965	1966	1967	1968	1969p
	($ million)					
Primary industries						
Agriculture	2,407	2,635	3,298	2,693	2,864	3,076
Forestry	556	603	673	685	725	839
Fishing	149	160	176	164	186	184
Trapping	13	12	14	10	12	16
Mining[1]	2,291	2,476	2,613	2,918	3,175r	3,342
Electric power	970	1,036	1,132	1,234	1,360	1,511
Total	6,386	6,922	7,906	7,704	8,322r	8,968
Secondary industries						
Manufacturing	13,536	14,928	16,352	17,006	18,252	20,131
Construction	3,391	3,987	4,843	5,148	5,269	5,794
Total	16,927	18,915	21,195	22,154	23,521	25,925
Grand total	23,313	25,837	29,101	29,858	31,843r	34,893

Note: Data revised to conform with revised Canadian Standard Industrial Classification and new establishment concept.

[1]Excludes cement, lime, clay and clay products (from domestic clays) manufacture. These industries in the above tables are included under Manufacturing.

pPreliminary; rRevised.

Table 10. Canada, Census Value Added, Mining and Mineral Manufacturing Industries, 1965-1969

	1965	1966	1967	1968	1969
			($000)		
Mining					
Metallic					
Placer gold	1,355	1,339	257	264	155
Gold quartz	94,529	93,028	85,352	78,032	74,993
Copper-gold-silver	207,118	277,015	357,488	377,800	465,309
Silver-cobalt	4,991	5,715	6,870	7,645	6,088
Silver-lead-zinc	177,317	158,242	138,912	150,565	171,239
Nickel-copper	386,247	314,102	377,487	437,372	386,383
Iron	243,281	250,393	289,595	339,402	315,378
Misc. metal mines	61,845	78,266	78,437	72,306	104,433
Total	1,176,683	1,178,100	1,334,398	1,463,386	1,523,978
Industrial Minerals					
Asbestos	118,896	134,694	136,918	143,591	157,855
Feldspar, quartz and nepheline	6,202	6,217	6,784	7,368	9,065
Gypsum	7,858	7,553	7,968	9,277	11,496
Peat	7,023	6,428	7,898	8,857	8,066
Salt	18,251	17,800	21,087	23,484	22,238
Sand and gravel	38,702	38,690	37,182	40,286	44,329
Stone	45,244	48,085	43,428	44,339	45,153
Talc and soapstone	702	748	640	824	785
Misc. nonmetals	59,543[r]	61,430	64,268	60,450	62,005
Total	302,421[r]	321,645	326,173	338,476	360,992
Fuels					
Coal	56,475	62,722	73,280	66,088[r]	64,321
Petroleum and natural gas	940,331	1,050,424	1,183,818	1,307,995	1,392,994
Total	996,806	1,113,146	1,257,098	1,374,083[r]	1,457,315
Total Mining Industry	2,475,910[r]	2,612,891	2,917,669	3,175,945[r]	3,342,285
Mineral Manufacturing					
Primary Metal Industries					
Iron and steel mills	646,100	648,228	617,092	684,684	708,727
Steel pipe and tube mills	58,232	60,996	56,820	73,884	75,525
Iron foundries	93,622	117,780	108,944	106,610	123,331
Smelting and refining	407,272	416,058	448,124	477,763	512,475
Aluminum rolling, casting and extruding	43,914	41,499	58,410	66,496	82,837
Copper and alloy rolling, casting and extruding	42,443	59,903	51,968	59,105	61,054
Metal rolling, casting and extruding, nes	41,340	42,739	42,251	46,365	55,867
Total	1,332,923	1,387,203	1,383,609	1,514,867	1,619,816
Nonmetallic Mineral Products Industries					
Cement manufacturers	104,081	111,048	100,496	107,088	117,521
Lime manufacturers	10,791	8,825	7,769	8,573	10,368
Gypsum products manufacturers	24,765	25,036	27,460	32,079	36,877
Concrete products manufacturers	106,130	118,548	116,742	122,789	126,965
Ready-mix concrete manufacturers	81,086	107,035	92,273	106,314	109,951
Clay products (domestic clay)	31,095	30,494	30,906	33,996	37,270
Clay products (imported clay)	21,272	23,814	23,195	24,652	22,399
Refractories manufacturers	14,324	14,895	16,132	16,924	19,759

Table 10. (Concl.)

	1965	1966	1967	1968	1969
			($000)		
Mineral Manufacturing (Cont'd)					
Stone products manufacturers	8,506	7,080	6,435	6,278	6,630
Mineral wool manufacturers	17,103	18,959	20,540	21,808	24,748
Asbestos products manufacturers	27,188	29,260	23,811	29,359	31,135
Glass manufacturers	56,779	63,651	71,631	93,692	100,230
Glass products manufacturers	38,518	37,471	40,175	43,396	50,784
Abrasives manufacturers	30,264	31,020	28,830	29,198	33,228
Other nonmetallic mineral products industries	8,252	8,487	8,914	9,895	11,074
Total	580,154	635,623	615,309	686,041	738,939
Petroleum and Coal Products Industries					
Petroleum refining	244,108	253,291	270,86	307,298	293,416
Manufacturers of lubricating oils and greases	13,479	14,645	14,338	13,635	15,486
Other petroleum and coal products industries	7,701	8,532	8,367	8,484	8,266
Total	265,288	276,468	292,791	329,417	317,168
Total Mineral Manufacturing	2,178,365[r]	2,299,294[r]	2,291,709	2,530,325	2,675,923
Total Mining and Mineral Manufacturing	4,654,275[r]	4,912,185[r]	5,209,378	5,706,270[r]	6,018,208

[r]Revised; nes Not elsewhere specified.

Table 11. Canada, Indexes of Physical Volume of Total Industrial Production, Mining and Mineral Manufacturing, 1956-1971 (1961=100)

	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968[r]	1969[r]	1970	1971[p]
Total Industrial Production	85.8	87.2	86.7	94.2	96.2	100.0	108.3	115.2	126.6	137.0	146.0	150.8	161.1	168.7	172.3	177.6
Total Mining	77.1	84.6	86.0	97.3	97.4	100.0	106.2	112.1	126.0	131.9	134.2	142.1	152.4	150.8	174.8	182.5
Metals																
All metals	72.7	85.5	95.5	110.0	107.3	100.0	102.2	104.1	120.2	122.8	121.1	129.3	135.9	122.1	147.4	149.1
Placer gold and gold quartz mines	98.4	100.0	104.1	102.2	104.4	100.0	95.1	91.4	90.1	87.4	82.2	73.6	66.8	59.5	55.6	52.6
Iron mines	93.0	97.4	70.7	105.2	103.6	100.0	139.3	170.4	208.6	224.8	241.5	260.7	314.8	268.3	342.0	332.7
Miscellaneous metal mines, nes	..	..	..	..	..	100.0	102.1	100.4	125.1	136.9	131.3	143.1	145.7	132.4	132.2	136.4
Fuels																
All fuels	80.0	83.1	76.5	84.1	87.1	100.0	114.3	123.0	133.0	142.0	152.4	166.1	181.5	198.8	234.7	253.9
Coal	149.5	131.1	113.8	103.8	107.0	100.0	97.9	104.5	109.8	111.9	103.7	103.1	102.6	99.1	153.9	193.0
Crude petroleum and natural gas	..	..	..	..	..	100.0	117.3	126.3	137.2	147.4	161.2	177.5	195.7	216.8	249.3	264.8
Nonmetals																
All nonmetals	88.6	84.8	80.3	92.0	91.5	100.0	108.7	121.4	139.2	151.5	164.2	173.6	189.7	203.2	206.4	212.0
Asbestos	86.4	83.8	79.8	86.4	90.3	100.0	103.2	109.0	121.9	118.2	127.7	125.6	132.7	133.9	137.5	137.3
Mineral Manufacturing																
Primary metals	..	..	..	..	..	100.0	105.5	114.3	128.4	140.4	146.1	141.1	159.6	160.7	170.8	173.4
Nonmetallic mineral products	86.7	88.4	91.8	99.0	95.8	100.0	115.0	116.7	128.0	139.3	144.9	135.4	147.2	147.8	140.4	145.8
Petroleum and coal products	79.7	81.5	82.3	90.2	94.1	100.0	108.7	117.2	118.5	124.4	129.1	130.5	144.3	147.6	155.9	165.2

[p]Preliminary; . . Not available; [r]Revised; nes Not elsewhere specified.

Table 12. Canada, Indexes of Real Domestic Products by Industries, 1962-1971 (1961=100)

	1962	1963	1964	1965	1966	1967	1968[r]	1969[r]	1970	1971[p]
Real domestic product, all industries	106.9	112.7	120.4	129.0	138.0	142.4	149.8	156.6	160.4	167.6
Agriculture	122.0	136.9	123.9	127.6	145.9	118.6	126.0	129.9	124.9	145.6
Forestry	106.4	108.3	119.2	122.5	132.7	130.3	131.2	142.1	146.1	146.0
Fishing and trapping	106.9	106.4	108.9	106.6	118.2	112.1	127.1	112.6	114.8	107.3
Mining (including milling) quarries and oil wells	106.2	112.1	126.0	131.9	134.2	142.1	152.4	150.8	174.8	182.5
Electric power, gas and water utilities	105.3	111.6	120.8	129.9	141.4	151.2	162.8	177.9	191.7	205.4
Manufacturing	109.0	116.2	127.4	138.8	148.7	152.3	162.5	171.0	169.5	173.5
Construction	105.6	107.1	117.4	131.6	141.7	141.2	147.4	151.3	148.3	160.9
Transportation, storage and communication	104.1	111.1	120.3	127.6	138.0	145.3	153.1	161.2	172.6	178.2
Trade	106.1	111.2	119.5	129.4	137.6	144.7	150.6	157.8	159.9	172.1
Community, business and personal service	105.4	110.9	119.0	128.8	140.4	150.4	158.2	167.4	174.4	179.7
Finance, insurance and real estate	105.5	110.5	115.0	120.8	125.6	131.4	135.0	140.6	144.2	148.2
Public administration and defence	103.1	104.0	106.3	108.3	112.2	118.2	121.5	123.7	127.2	133.4

[p]Preliminary; [r]Revised.

Table 13. Canada, Exports of Crude Minerals and Fabricated Mineral Products by Main Groups, 1967-1971

	1967	1968	1969	1970	1971
			($ million)		
Ferrous					
Crude material	398.2	458.3	363.5	508.9	431.8
Fabricated material	286.0	384.9	352.9	487.3	463.6
Total	684.2	843.2	716.4	996.2	895.4
Nonferrous					
Crude material	617.7	803.9	775.2	993.8	954.8
Fabricated material[1]	1,170.0	1,297.5	1,286.2	1,689.7	1,389.7
Total	1,787.7	2,101.4	2,061.4	2,683.5	2,344.5
Nonmetals					
Crude material	274.7	320.7	336.7	453.2	456.9
Fabricated material	146.1	166.2	178.5	99.8	100.6
Total	420.8	486.9	515.2	553.0	557.5
Mineral fuels					
Crude material	537.1	621.2	711.7	884.6	1,124.6
Fabricated material	39.6	50.4	58.9	85.1	117.0
Total	576.7	671.6	770.6	969.7	1,241.6
Total minerals and products					
Crude material	1,827.7	2,204.1	2,187.1	2,840.5	2,968.1
Fabricated material	1,641.7	1,899.0	1,876.5	2,361.9	2,070.9
Total	3,469.4	4,103.1	4,063.6	5,202.4	5,039.0

[1] Includes gold, refined and unrefined.

Table 14. Canada, Value of Imports of Crude Minerals and Fabricated Mineral Products by Main Groups, 1967-1971

	1967	1968	1969	1970	1971
			($ million)		
Ferrous					
Crude material	48.0	48.7	47.5	54.4	50.9
Fabricated material	551.0	537.1	723.6	718.4[r]	805.0
Total	599.0	585.8	771.1	772.8	855.9
Nonferrous[1]					
Crude material	131.9	172.5	145.7	188.9	192.0
Fabricated material	269.0	298.2	328.2	277.5[r]	301.4
Total	400.9	470.7	473.9	466.4	493.4
Nonmetals					
Crude materials	66.2	63.6	63.8	63.7	73.1
Fabricated material	149.3	141.2	165.6	165.9[r]	180.3
Total	215.5	204.8	229.4	229.6	253.4
Mineral fuels					
Crude material	521.8	568.8	493.6	571.4	699.9
Fabricated material	198.4	216.0	223.5	205.7	65.4
Total	720.2	784.8	717.1	777.1	765.3
Total minerals and products					
Crude material	767.9	853.6	750.6	878.4	1,015.9
Fabricated material	1,167.7	1,192.5	1,440.9	1,367.5[r]	1,352.1
Total	1,935.6	2,046.1	2,191.5	2,245.9[r]	2,368.0

[1]Includes gold, refined and unrefined; [r]Revised.

Table 15. Canada, Value of Exports of Crude Minerals and Fabricated Mineral Products in Relation to Total Export Trade, 1967-1971

	1967		1968		1969		1970		1971	
	($ million)	(% of total)	($ million)	(% of total)	($ million)	(% of total)	($ million)	(% of total)	($ million)	(% of total)
Crude material	1,827.7	16.4	2,204.1	16.6	2,187.1	14.9	2,840.5[r]	16.9	2,968.1	16.7
Fabricated material[1]	1,641.7	14.8	1,899.0	14.3	1,876.5	12.6	2,361.9[r]	14.0	2,070.9	11.7
Total	3,469.4	31.2	4,103.1	30.9	4,063.6	27.3	5,202.4	30.9	5,039.0	28.4
Total exports[1] all products	11,111.6	100.0	13,251.0	100.0	14,890.0[r]	100.0	16,820.1[r]	100.0	17,743.6	100.0

[1]Includes gold refined and unrefined; [r]Revised.

Table 16. Canada, Value of Imports of Crude Minerals and Fabricated Mineral Products in Relation to Total Import Trade, 1967-1971

	1967		1968		1969		1970		1971	
	($ million)	(% of total)	($ million)	(% of total)	($ million)	(% of total)	($ million)	(% of total)	($ million)	(% of total)
Crude material	767.9	6.9	853.6	6.9	750.6	5.3	878.4	6.3	1,015.9	6.5
Fabricated material[1]	1,167.7	10.5	1,192.5	9.6	1,440.9	10.2	1,367.5[r]	9.8	1,352.1	8.7
Total	1,935.6	17.4	2,046.1	16.5	2,191.5	15.5	2,245.9[r]	16.1	2,368.0	15.2
Total imports[1] all products	11,075.2	100.0	12,358.0	100.0	14,130.3	100.0	13,951.9[r]	100.0	15,606.6	100.0

[1]Includes gold, refined and unrefined; [r]Revised.

Table 17. Canada, Value of Exports of Crude Minerals and Fabricated Mineral Products by Main Groups and Destination, 1971

	Britain	United States	Other Countries	Total
	($ million)			
Ferrous materials and products	74.9	634.7	185.8	895.4
Nonferrous[1] materials and products	494.4	899.5	950.6	2,344.5
Nonmetallic mineral materials and products	24.6	311.1	221.8	557.5
Mineral fuels, materials and products	1.1	1,143.6	96.9	1,241.6
Total	595.0	2,988.9	1,455.1	5,039.0
Percentage	11.8	59.3	28.9	100.0

[1]Includes gold, refined and unrefined.

Table 18. Canada, Value of Imports of Crude Minerals and Fabricated Mineral Products by Main Groups and Country of Origin, 1971

	Britain	United States	Other Countries	Total
	($ million)			
Ferrous materials and products	62.0	542.1	251.7	855.9
Nonferrous[1] materials and products	23.0	272.4	198.1	493.4
Nonmetallic mineral materials and products	11.8	177.6	64.0	253.4
Mineral fuels, materials and products	3.4	208.6	553.3	765.3
Total	100.2	1,200.7	1,067.1	2,368.0
Percentage	4.2	50.7	45.1	100.0

[1]Includes gold, refined and unrefined.

Table 19. Canada, Value of Exports of Crude Minerals and Fabricated Mineral Products, by Commodity and Destination, 1971

	U.S.A.	Britain	Other[1] EFTA Countries	EEC[2] Countries	Japan	Other Countries	Total
				($000)			
Aluminum	232,676	61,137	20,286	14,985	42,677	94,916	466,677
Asbestos	81,149	17,337	8,797	42,091	13,561	66,730	229,665
Copper	179,399	113,341	50,602	73,122	151,279	36,531	604,274
Fuels	1,143,585	1,086	685	5,482	87,664	3,082	1,241,584
Iron ore	274,790	50,617	–	50,311	27,139	10,475	413,332
Lead	5,745	10,503	121	11,232	22,830	18,399	68,830
Molybdenum	14	10,995	2,173	21,891	8,623	1,209	44,905
Nickel	279,750	231,511	127,969	23,659	29,934	21,527	714,350
Primary ferrous metals	48,340	8,060	229	15,649	718	15,599	88,595
Uranium	6,214	11,473	–	–	–	–	17,687
Zinc	73,265	20,373	2,158	72,883	29,303	17,313	215,295
All other minerals[3]	663,987	58,556	6,071	54,204	29,758	121,275	933,851
Total	2,988,914	594,989	219,091	385,509	443,486	407,056	5,039,045

[1]Other European Free Trade Association countries: Austria, Denmark, Norway, Portugal, Sweden and Switzerland. [2]European Economic Community (Common Market) countries: Belgium, France, Italy, Luxembourg, Netherlands and West Germany. [3]Includes gold, refined and unrefined.
– Nil.

Table 20. Canada Reported Consumption of Minerals

		1968			
		Consumption	Production	Consumption as % of Production	Consumption
Metals					
Aluminum	st	242,390	979,171	24.7	269,027
Antimony	lb	1,169,631	1,159,960	100.8	1,305,742
Bismuth	lb	59,300	648,232	9.2	33,800
Cadmium	lb	125,000	5,014,965	2.5	132,136
Chromium (chromite)	st	77,075	–	. .	68,484
Cobalt	lb	358,098	4,029,549	8.9	393,658
Copper	st	250,104[1]	633,313	39.5	226,281[1r]
Lead	st	94,660[2]	340,175	27.8	105,915[2]
Magnesium	st	5,654	9,929	57.0	5,672
Manganese ore	st	124,904	–	. .	168,485
Mercury	lb	327,939	. .	. .	308,814
Molybdenum (Mo content)	lb	1,543,432	22,464,273	6.9	1,808,772[r]
Nickel	st	11,233	264,358	4.2	12,094
Selenium	lb	21,440	635,510	3.4	15,572
Silver	oz	13,598,358	45,012,797	30.2	5,747,068
Tellurium	lb	4,605	70,991	6.5	3,532
Tin	lt	4,251	160	2,656.9	4,280
Tungsten (W content)	lb	1,181,541	3,584,920	33.0	1,050,824
Zinc	st	115,978[3]	1,159,392	10.0	118,681[3]
Nonmetals					
Barite	st	22,403	138,059	16.2	24,151
Feldspar	st	7,343	10,620	69.1	7,635[r]
Fluorspar	st	178,901	105,000[e]	170.4	200,827
Mica	lb	3,932,000	–	. .	5,368,000
Nepheline syenite	st	79,566	426,595	18.7	78,314[r]
Phosphate rock	st	2,234,259	–	. .	1,822,069
Potash (K_2O)[4]	st	183,100	2,971,206	6.2	185,527
Sodium sulphate	st	391,953	459,669	85.3	437,055[r]
Sulphur, elemental	st	830,147	2,580,746	32.2	770,846
Talc, etc.	st	32,931	80,589	40.9	38,093[r]
Fuels					
Coal	st	27,317,782[r]	10,989,007	248.6	26,455,330[r]
Natural gas	Mcf	765,786,814[5]	1,692,300,787	45.3	843,164,967[5]
Petroleum, crude	bbl	413,471,510[6]	379,491,577	109.0	432,513,825[6]

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

and Relation to Production, 1968-71

1969		1970			1971p		
Production	Consumption as % of Production	Consumption	Production	Consumption as % of Production	Consumption	Production	Consumption as % of Production
1,078,717	24.9	275,743	1,071,718	25.7	284,985[1]	1,120,951	25.4
820,122	159.2	1,142,009	726,474	157.2	..	330,000	..
579,059	5.8	24,548	590,340	4.2	..	267,000	..
5,213,054	2.5	124,959	4,307,953	2.9	..	4,132,000	..
–	..	61,963	–	..	61,313	–	..
3,255,623	12.1	327,030	4,561,213	7.2	220,994	4,992,000	4.4
573,246	39.5	237,838[1]	672,717	35.4	221,053[1]	714,507	30.9
318,632	33.2	94,094[2]r	389,185	24.2	94,617[2]	406,685	23.3
10,637	53.3	4,937	10,353	47.7	6,276	7,252	86.5
–	..	169,586	–	..	174,761	–	..
..	..	340,558	..	..	193,968	..	..
29,651,261	6.1	2,286,061	33,771,716	6.8	1,814,586	28,324,000	6.4
213,612	5.7	11,794	305,881	3.9	..	293,947	..
599,415	2.6	15,730	663,336	2.4	15,686	718,000	2.2
43,530,941	13.2	6,034,028	44,250,804	13.6	6,842,620	44,938,000	15.2
62,048	5.7	880	58,333	1.5	1,178	24,000	4.9
129	3,317.8	4,482	118	3,798.3	3,992	131	3,047.3
4,063,488	25.9	984,777	3,726,800	26.4	639,765	5,008,600	12.8
1,207,625	9.8	105,641[3]r	1,251,911	8.4	111,641[3]	1,227,375	9.1
143,230	16.9	34,935	147,251	23.7	..	137,000	..
12,385	61.6	7,676	10,656	72.0	..	10,000	..
110,000e	182.6	212,949	137,000e	155.4	..	100,000e	..
–	..	5,746,000	–	..	..	–	..
500,571	15.6	83,360	486,667	17.1	..	500,000	..
–	..	1,896,684	–	..	..	–	..
3,085,995	6.0	194,149	3,930,662	4.9	203,193	3,219,869	6.3
518,299	84.3	425,071	490,547	86.7	..	480,000	..
2,973,506	25.9	889,992	3,548,310	25.1	850,000e	3,065,000	27.7
75,850	50.2	35,432	72,055	49.2	..	67,000	..
10,671,879	247.9	29,957,279	16,604,164r	180.4	..	19,351,363	..
1,977,932,414	42.6	917,440,879[5]	2,277,108,791	40.3	1,001,316,902[5]	2,500,751	40.0
410,989,652	105.2	467,306,197[6]	461,180,059	101.3	508,288,096[6]	492,568,491	103.2

fuels, production is equivalent to actual output less waste. [1]Producers' domestic shipments of refined metal. [2]Includes primary and secondary refined lead. [3]Primary refined zinc only. [4]Production and consumption for year ended June 30. [5]Domestic sales. [6]Refinery receipts.

pPreliminary; rRevised; eEstimates; – Nil; . . Not available or not applicable.

Table 21. Canada, Apparent Consumption[1] of Some Minerals

		1968			
		Apparent Consumption	Production	Consumption as % of Production	Apparent Consumption
Asbestos	st	142,233	1,595,951	8.9	53,855
Cement	st	7,850,799	8,165,805	96.1	7,669,220
Gypsum	st	1,532,397	5,926,940	25.9	1,584,263
Iron ore	lt	9,098,962	42,360,092	21.5	10,116,993
Lime	st	1,395,520	1,456,013	95.8	1,480,928
Quartz (silica)	st	3,597,479	2,554,565	140.8	3,504,114
Salt	st	4,056,000[e]	4,864,324	83.4	4,338,000[e]

[1]Apparent Consumption = Production plus imports less exports. [2]Production = Producers' shipments.
[p]Preliminary; [e]Estimated.

and Relation to Production[2], 1968-1971

1969		1970			1971p		
Production	Consumption as % of Production	Apparent Consumption	Production	Consumption as % of Production	Apparent Consumption	Production	Consumption as % of Production
1,611,168	3.3	105,045	1,661,644	6.3	92,026	1,641,000	5.6
8,250,032	93.0	7,476,585	7,945,915	94.1	8,702,028	9,534,000	91.3
6,373,648	24.9	1,504,099	6,318,523	23.8	1,870,809	6,800,000	27.5
35,762,745	28.3	10,107,938	46,708,946	21.6	11,018,414	43,281,000	25.5
1,634,862	90.6	1,481,125	1,647,954	89.9	1,261,707	1,519,000e	83.1
2,300,374	152.3	4,469,629	3,238,037	138.0	3,845,614	2,526,000	152.2
4,657,765	93.1	4,739,000e	5,358,896	88.4	5,357,000e	5,578,000	96.0

Table 22. Canada, Domestic Consumption of Principal Refined Metals in Relation to Production[1], 1962-1971

		1962	1963	1964	1965	1966	1967	1968	1969	1970	1971[p]
Copper											
Domestic consumption[2]	st	151,525	169,750	202,225	224,684	262,557	219,680	250,104	226,281[r]	237,838	221,053
Production	st	382,868	380,075	407,942	434,133	433,004	499,846	524,474	449,232[r]	543,071	526,401
Consumption of Production	%	39.6	44.7	49.6	51.8	60.6	43.9	47.7	50.4	43.8	42.0
Zinc											
Domestic consumption[3]	st	65,320	73,653	88,494	93,796	107,052	107,779	115,978	118,681	108,364	114,334
Production	st	280,158	284,021	337,734	358,498	382,605	405,136	426,728[r]	466,357[r]	460,663	410,030
Consumption of Production	%	23.3	25.9	26.2	26.2	28.0	26.6	27.2	25.4	23.5	27.9
Lead											
Domestic consumption[3]	st	77,286	77,958	82,736	90,168	96,683	93,953	94,660	105,915	94,094	94,617
Production	st	152,217	155,000	151,372	186,484	184,871	193,235	202,100	187,142	204,630	185,582
Consumption of Production	%	50.8	50.3	54.7	48.4	52.3	48.6	46.8	56.6	46.0	51.0
Aluminum											
Domestic consumption[3]	st	151,898	161,833	172,443	213,094	243,301	217,484	242,390	269,027	275,743	284,985[2]
Production	st	690,297	719,390	842,640	830,505	889,915	963,343	979,171	1,078,717[r]	1,071,718	1,120,951[2]
Consumption of Production	%	22.0	22.5	20.5	25.7	27.3	22.6	24.8	24.9	25.7	25.4

[1] Production of refined metal from all sources, including metal derived from secondary materials at primary refineries. [2] Producers' domestic shipment of refined metal. [3] Consumption primary and secondary refined metal, reported by consumers.
[r] Revised; [p] Preliminary.

Table 23. Annual Averages of Prices of Main Metals[1], 1967-1971

		1967	1968	1969	1970	1971
Aluminum ingot, 99.5%	cents/lb	25.000	25.583	27.176	28.716	29.000
Antimony, R.M.M. fob Loredo, Texas	cents/lb	44.000	44.000	55.700	141.640	69.300
Bismuth, ton lots delivered	$/lb	4.000	4.000	4.625	6.000	5.260
Cadmium	cents/lb	264.722	270.000	331.917	362.452	197.262
Calcium, ton lots, crowns	$/lb	0.95	0.95	0.95	0.95	0.95
Chromium metal, 98.5% 0.5%C	$/lb	0.97	0.96	0.97	1.15	1.15
Cobalt metal, 500 lb lots	$/lb	1.850	1.850	1.910	2.20	2.20
Copper, U.S. domestic, fob refinery	cents/lb	38.226[2]	41.847[3]	47.534	57.700	51.433
Gold, Canadian dollars	$/troy oz	37.75	37.71	37.70	36.56	35.35
Iron ore, 51.5% Fe, lower lake ports						
Bessemer						
Mesabi	$/lt	10.70	10.70	10.69	10.55-10.95	11.25
Old Range	$/lt	10.95	10.95	10.95	10.95-11.20	11.51
Non-Bessemer						
Mesabi	$/lt	10.55	10.55	10.55	10.55-10.80	11.11
Old Range	$/lt	10.80	10.80	10.80	10.80-11.05	11.36
Lead, common, New York	cents/lb	14.000	13.212	14.895	15.619	13.800
Magnesium, ingot	cents/lb	35.250	35.250	35.250	35.250	36.250
Mercury	$flask(76 lb)	489.355	535.555	505.043	407.769	292.413
Molybdenum metal	$/lb	3.66	3.69	3.82	4.00	4.00
Molybdenite, 95% MoS_2 contained Mo	$/lb	1.62	1.62	1.68	1.73	1.72
Nickel, fob Port Colborne (duty free)	cents/lb	87.774	94.071	105.431	129.080	133.000
Platinum	$/Troy oz	108.509	114.500	121.667	130.00	120.524
Selenium	$/lb	4.50	4.50	5.31	8.25	9.00
Silver, New York	cents/troy oz	154.968	214.460	179.067	177.082	154.564
Tin, Straits, New York	cents/lb	153.434	148.151	164.347	174.205	167.348
Titanium metal, 500 lb lots 99.3%	$/lb	1.32	1.32	1.32	1.32	1.32
Titanium ore (ilmenite) 54% TiO_2	$/st	22.50	20.50	20.50	20.21	20.21
Tungsten metal	$/st	2.75	2.75	2.75	4.50	4.50
Zinc, prime western East St. Louis	cents/lb	13.843	13.500	14.600	15.319	16.128

[1]These prices, except for gold, are in United States currency, and are from *Metals Week*. [2]Average first eight months because of price quote suspension September through December. [3]Average last nine months because of price quote suspension January through March.

Table 24. Canada, Wholesale Price Indexes of Minerals and Mineral Products, 1968-1971 (1935-39 = 100)

	1968	1969	1970	1971
Iron and products	276.8	285.8	305.1	316.4
Pig iron	285.1	285.8	304.2	313.5
Rolling mill products	263.0	275.8	291.7	306.7
Pipe and tubing	302.3	304.4	309.2	321.4
Wire	300.2	314.2	347.3	368.3
Scrap iron and steel	252.7	250.0	328.9	284.2
Tin plate and galvanized sheet	257.2	258.8	267.2	282.5
Nonferrous metals and products				
Total (including gold)	250.8	264.0	281.0	260.1
Total (excluding gold)	365.8	389.6	422.9	387.6
Copper and products	455.0	493.1	511.5	440.3
Lead and products	281.2	318.4	330.5	282.9
Silver	602.8	497.5	478.1	405.6
Tin	305.8	338.0	349.6	324.2
Zinc and products	307.7	333.8	349.2	365.9
Nonmetallic minerals and products	206.0	210.0	215.7	225.8
Clay and clay products	259.5	265.8	274.6	280.3
Pottery	261.7	280.8	304.9	313.9
Coke	284.8	288.4	347.4	413.4
Petroleum products	164.1	165.5	170.8	182.6
Asphalt	197.7	197.7	197.7	225.2
Asphalt shingles	115.4	123.7	135.0	144.0
Plaster	171.7	181.3	183.1	185.0
Lime	259.7	273.7	282.1	299.4
Cement	193.1	201.2	207.9	216.4
Sand and gravel	168.8	185.2	186.9	187.8
Crushed stone	165.3	171.9	177.4	180.2
Building stone	256.3	257.7	266.9	282.6
Asbestos	348.8	366.3	375.9	383.2
General wholesale price index				
(all products)	269.9	282.4	286.4	289.9

Table 25. Canada, General Wholesale Price Index and Wholesale Price Indexes of Mineral and Nonmineral Products, 1947-1971 (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
1947	140.7	130.2	129.1	157.3	183.0	179.5	208.8	136.7	163.3
1948	161.4	146.9	150.8	185.7	236.7	216.3	238.3	152.2	193.4
1949	175.5	145.2	158.3	190.5	237.5	222.5	241.6	155.2	198.3
1950	183.6	159.5	164.8	202.0	251.3	246.7	258.3	157.8	211.2
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	250.4
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	237.1	326.0	261.9	394.4	237.8	289.9

Table 26. Canada, Mineral Products Industries, Selling Price Indexes, 1968-1971 (Base year 1961=100)

	1968	1969	1970	1971
Iron and steel products industries				
Agriculture implements industry	114.3	118.5	122.1	125.5
Hardware, tool and cutlery manufacturers	115.7	121.0	126.5	130.9
Heating equipment manufacturers	104.5	107.6	111.1	113.5
Primary metal industries	120.5	129.0	136.9	132.3
Iron and steel mills	103.0	106.7	112.6	117.9
Steel pipe and tube mills	95.3	95.5	98.9	103.0
Iron foundries	119.0	122.0	127.7	131.4
Wire and wire products manufacturers	106.1	110.1	119.5	124.5
Nonferrous metal products industries				
Aluminum rolling, casting and extruding	104.3	107.2	109.7	109.8
Copper and alloy, rolling, casting and extruding	150.9	164.7	181.0	169.4
Jewellery and silverware manufacturers	142.3	144.0	148.5	145.5
Metal rolling, casting and extruding, nes	141.7	158.1	176.0	151.0
Nonmetallic metal products industries				
Abrasive manufacturers	108.9	110.3	112.2	110.9
Cement manufacturers	116.3	121.1	125.8	130.3
Clay products manufacturers from imported clay	112.3	115.5	116.9	121.2
Glass manufacturers	114.2	119.3	125.4	130.6
Lime manufacturers	119.6	124.4	129.1	138.3
Gypsum products manufacturers	112.0	117.0	119.4	119.5
Concrete products manufacturers	116.7	120.5	125.4	127.5
Clay products from domestic clay	112.6	118.3	121.1	124.6
Petroleum and coal products industries	98.1	100.1	103.1	113.9
Petroleum refining	97.8	99.7	102.8	113.7
Lubricating oils and greases	117.0	121.4	122.2	128.4
Manufacturers of mixed fertilizers	116.6	110.0	108.9	112.8

Note: Industry selling price indexes reflect wholesale price trends of products or groups of products sold by the industries listed.
nes Not elsewhere specified.

Table 27. Canada, Principal Statistics of the Mining Industry, 1969

	Mining Activity								Total Activity		
		Production			Costs						
	Establishments	Workers	Man-hours Paid	Wages	Fuel and Electricity	Materials and Supplies	Value of Production	Value Added	Employees	Salaries and Wages	Value Added
			($000)	($000)	($000)	($000)	($000)	($000)		($000)	($000)
Metals											
Placer gold	9	12	10	36	13	58	226	155	13	36	156
Gold quartz	37	6,947	14,330	39,112	5,314	27,887	108,193	74,993	8,208	48,805	75,573
Copper-gold-silver	43	10,627	21,944	73,721	13,550	228,250	707,109	465,309	13,378	96,233	467,564
Silver-cobalt	7	430	909	2,599	317	1,825	8,230	6,088	512	3,176	6,165
Silver-lead-zinc	21	4,772	10,177	34,191	7,446	117,701	296,386	171,239	5,955	44,480	170,424
Nickel-copper	9	12,425	24,945	94,999	8,329	257,253	651,965	386,383	15,301	128,203	387,706
Iron	18	7,058	15,369	66,960	32,143	114,322	461,843	315,378	10,490	101,290	316,009
Misc. metal mines	17	3,752	8,108	29,877	5,982	32,972	143,387	104,433	4,904	39,614	105,192
Sales and head office									1,789	17,414	1,264
Total	161	46,023	95,792	341,495	73,094	780,268	2,377,339	1,523,978	60,550	479,251	1,530,053
Nonmetals											
Asbestos	12	5,855	14,293	45,781	11,310	31,943	201,108	157,855	7,242	58,557	157,574
Feldspar, quartz and nepheline syenite	13	316	703	1,880	625	2,113	11,804	9,065	388	2,447	9,053
Gypsum	12	544	1,215	3,113	706	2,528	14,731	11,496	657	4,004	11,424
Peat	68	1,040	2,260	3,956	508	3,941	12,515	8,066	1,157	4,820	8,106
Salt	10	771	1,702	4,740	1,343	5,616	29,197	22,238	1,196	7,978	22,182
Sand and gravel	175	1,902	4,450	11,822	3,452	8,276	56,057	44,329	2,440	16,549	45,578
Stone	152	2,670	6,154	15,496	4,859	17,516	67,529	45,153	3,252	19,813	45,415
Talc and soapstone	4	82	189	372	71	364	1,219	785	108	526	794
Misc. nonmetallics	20	2,753	5,848	20,462	10,048	19,046	91,097	62,005	3,574	27,908	61,444
Total	466	15,933	36,814	107,622	32,922	91,343	485,257	360,992	20,014	142,602	361,570
Fuels											
Coal	42	5,866	10,997	34,178	3,505	19,743	87,569	64,321	7,371	44,738	64,051
Petroleum and natural gas	1,017	3,546	7,469	30,413	17,478	40,000	1,450,472	1,392,994	14,153	138,248	1,399,638
Total	1,059	9,412	18,466	64,591	20,983	59,743	1,538,041	1,457,315	21,524	182,986	1,463,689
Total Mining Industry	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

Note: Total activity in this table and also in Tables 28, 29 and 30 includes sales and head offices.

Table 28. Canada, Principal Statistics of the Mineral Manufacturing Industries, 1969

	Mineral Manufacturing Activity								Total Activity		
		Production			Costs						
	Establishments	Workers	Man-hours Paid	Wages	Fuel and Electricity	Materials and Supplies	Value of Production	Value Added	Employees	Salaries and Wages	Value Added
			(000)	($000)	($000)	($000)	($000)	($000)		($000)	($000)
Primary metal industries											
Iron and steel mills	45	34,441	74,489	252,722	54,220	666,242	1,423,256	708,727	42,954	334,233	717,762
Steel pipe and tube mills	25	3,920	8,634	28,374	4,091	163,525	251,946	75,525	5,146	36,690	75,491
Iron foundries	126	9,943	21,489	63,877	5,621	83,242	209,075	123,331	11,582	78,306	126,154
Smelting and refining	24	23,940	47,917	167,783	69,612	400,248	982,335	512,475	33,376	253,201	527,438
Aluminum rolling, casting and extruding	66	4,548	9,645	28,513	3,649	161,419	244,887	82,837	6,028	41,491	83,184
Copper and alloy, rolling and extruding	50	3,076	6,868	22,165	2,717	233,000	296,112	61,054	3,922	29,743	61,134
Metal rolling and extruding	81	3,696	7,913	20,064	2,591	109,488	165,479	55,867	4,856	29,641	58,816
Total, primary metal industries	417	83,564	176,955	583,498	142,501	1,817,164	3,573,090	1,619,816	107,864	803,305	1,649,979
Nonmetallic mineral products industries											
Cement manufacturers	25	2,499	5,477	19,181	21,869	25,568	164,941	117,521	3,778	30,409	116,977
Lime manufacturers	13	580	1,226	3,438	3,341	4,201	17,860	10,368	707	4,427	10,299
Gypsum products manufacturers	15	1,218	2,699	8,453	2,589	22,204	61,164	36,877	1,555	11,009	38,901
Concrete products manufacturers	488	7,823	17,357	46,676	5,806	81,989	215,033	126,965	10,011	64,598	131,336
Ready-mix concrete manufacturers	307	5,636	12,990	38,368	8,072	149,870	267,677	109,951	7,509	53,043	116,403
Clay products manufacture (domestic)	78	2,829	6,113	15,955	6,547	8,516	51,047	37,270	3,395	20,444	37,340
Clay products manufacture (imported)	40	1,582	3,270	8,722	1,198	11,137	34,541	22,399	1,988	11,441	22,690
Refractories manufacturers	19	650	1,404	4,042	1,156	15,118	35,452	19,759	1,132	7,896	20,587
Stone products manufacturers	85	497	1,045	2,430	241	3,694	10,393	6,630	673	3,606	6,669

Table 28. (Concl.)

	Estab-lish-ments	Workers	Man-hours Paid	Wages	Fuel and Elec-tricity	Materials and Supplies	Value of Production	Value Added	Employees	Salaries and Wages	Value Added
	Mineral Manufacturing Activity								Total Activity		
		Production			Costs						
			(000)	($000)	($000)	($000)	($000)	($000)		($000)	($000)
Nonmetallic mineral products industries (Cont'd)											
Glass manufacturers	15	6,709	14,671	44,534	8,183	35,269	140,344	100,230	8,052	54,492	103,976
Glass products manufacturers	113	2,957	6,510	19,191	1,839	59,907	110,289	50,784	3,979	27,850	52,446
Mineral wool manufacturers	9	818	1,847	5,990	1,657	12,618	39,063	24,748	1,074	7,961	25,003
Asbestos products manufacturers	15	1,877	4,288	13,448	1,312	19,671	50,278	31,135	2,596	18,891	33,058
Abrasive manufacturers	22	1,963	4,294	13,244	7,401	27,408	67,572	33,228	2,697	19,626	33,994
Other nonmetallic mineral products industries	42	471	1,014	2,524	627	9,535	21,203	11,074	744	4,746	11,641
Total nonmetallic minerals	1,286	38,109	84,205	246,196	71,838	486,705	1,286,857	738,939	49,890	340,439	761,320
Petroleum and coal products industries											
Petroleum refining industry	41	5,971	13,444	57,140	17,587	1,350,114	1,661,250	293,416	8,765	86,393	302,139
Manufacturers of lubricating oils and greases	19	234	509	1,688	228	23,963	38,873	15,486	438	3,417	16,566
Other petroleum and coal products industries	39	385	834	2,389	707	11,391	20,217	8,266	532	3,541	10,105
Total petroleum and coal products industries	99	6,590	14,787	61,217	18,522	1,385,468	1,720,340	317,168	9,735	93,351	328,810
Total mineral manufacturing industries	1,802	128,263	275,947	890,911	232,861	3,689,337	6,580,287	2,675,923	167,489	1,237,095	2,740,109

Table 29. Canada, Principal Statistics of the Mining Industry[1], 1964-1969

	Mining Activity								Total Activity		
		Production			Costs						
	Establishments	Workers	Man-hours Paid	Wages	Fuel and Electricity	Materials and Supplies	Value of Production	Value Added	Employees	Salaries and Wages	Value Added
			(000)	($000)	($000)	($000)	($000)	($000)		($000)	($000)
1964	1,423	72,337	157,227	364,766	82,277	558,369	2,931,700	2,291,054	96,457	530,727	2,325,515
1965	1,467	75,046	162,542	396,731	96,393	650,139	3,222,441	2,475,910	100,820	582,101	2,514,269
1966	1,422	74,195	158,156	419,496	98,867	706,109	3,417,868	2,612,891	102,063	629,232	2,636,524
1967	1,478	74,230	159,182	465,489	107,563	806,577	3,831,808	2,917,669	102,678	700,678	2,943,224
1968	1,548	75,066	160,346	510,003	119,640	900,344	4,195,930[r]	3,175,945[r]	104,916	772,453	3,189,271[r]
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

[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 32.
[r]Revised.

Table 30. Canada, Principal Statistics of the Mineral Manufacturing Industries[1], 1964-1969

	Mineral Manufacturing Activity								Total Activity		
		Production			Costs						
	Establishments	Workers	Man-hours Paid	Wages	Fuel and Electricity	Materials and Supplies	Value of Production	Value Added	Employees	Salaries and Wages	Value Added
			(000)	($000)	($000)	($000)	($000)	($000)		($000)	($000)
1964	1,823	120,536	262,905	636,796	174,568	2,777,039	4,883,688	1,936,148	155,297	860,436	1,990,667
1965	1,842	128,514	279,340	710,220	194,895	2,995,152	5,322,623	2,178,365	163,837	951,414	2,238,542
1966	1,844	134,141	289,377	773,247	209,020	3,242,891	5,701,881	2,299,294	171,452	1,043,324	2,359,168
1967	1,797	131,090	282,982	801,636	210,519	3,241,716	5,692,956	2,291,709	169,441	1,095,187	2,342,764
1968	1,760	130,909	279,997	850,059	227,679	3,537,700	6,264,415	2,530,325[r]	173,932	1,188,721	2,588,302
1969	1,802	128,263	275,947	890,911	232,861	3,689,337	6,580,287	2,675,923	167,489	1,237,095	2,740,109

[1]Industry coverage in this table is the same as in Tables 28, 33 and 34.
[r]Revised.

Table 31. Canada, Consumption of Fuel and Electricity in the Mining Industry[1], 1969

		Metals	Nonmetals	Fuels	Total
	(000)				
Coal and coke	st	68	62	...	130
	$	1,088	534	3	1,625
Gasoline	gal	4,241	7,998	965	13,204
	$	1,667	3,019	323	5,009
Fuel oil, kerosene, coal oil	gal	151,375	71,012	2,103	224,490
	$	18,987	11,358	392	30,737
Liquified petroleum gas	gal	3,685	264	143	4,092
	$	583	81	18	682
Natural gas	Mcf	9,871	17,768	7	27,646
	$	4,624	4,774	3	9,401
Other fuels[2]	$	121	27	–	148
Total fuels	$	27,070	19,793	739	47,602
Electricity purchased	million kwh	7,073	1,473	1,265	9,811
	(000) $	46,002	12,728	20,244	78,974
Total value of fuels and electricity purchased	$	73,072	32,521	20,983	126,576
Value of fuels and electricity of small establishments[3]	$	22	401	–	423
Total value of fuels and electricity purchased, all reporting companies	$	73,094	32,922	20,983	126,999
Electricity generated by industry for own use	million kwh	380	170	–	550
Electricity generated by industry for sale	million kwh	96	–	–	96

[1]Excludes cement and lime manufacturing and manufacture of clay products (from domestic clays). These industries are included under mineral manufacturing, Tables 33 and 34. Industry coverage is the same as in Tables 27, 29 and 32.
[2]Includes wood, manufactured gas, steam purchased and other miscellaneous fuels.
[3]Value of fuels and electricity used by small establishments which have reported in total only without commodity detail.
. . . less than 1,000 units; – Nil.

Table 32. Canada, Cost of Fuel and Electricity in the Mining Industry[1], 1962-1969

		1962	1963	1964	1965	1966	1967	1968	1969
Metals									
Fuel	$000	13,737	15,551	16,246	19,854	22,038	26,116	29,340	27,070
Electricity purchased	million kwh	3,373	3,711	4,371	5,533	5,511	6,300	7,020	7,073
	$000	23,621	25,456	27,810	34,517	35,248	38,342	42,340	46,002
Value of fuel and electricity used by small establishments[2]	$000	–	–	59	57	5.	24	21	22
Total cost of fuel and electricity	$000	37,358	41,007	44,115	54,428	57,337	64,482	71,701	73,094
Electricity generated for own use and for sale	million kwh	599	465	447	483	473	510	466	476
Nonmetals									
Fuel	$000	11,201	11,928	12,279	14,623	15,410	16,180	18,448	19,793
Electricity purchased	million kwh	703	861	820	939	1,022	1,127	1,291	1,473
	$000	6,796	7,687	7,901	8,711	8,867	9,537	10,809	12,728
Value of fuel and electricity used by small establishments[2]	$000	–	–	703	740	735	548	342	401
Total cost of fuel and electricity	$000	17,997	19,615	20,883	24,074	25,012	26,265	29,599	32,922
Electricity generated for own use and for sale	million kwh	34	35	34	41	123	151	156	171
Fuels									
Fuel	$000	5,971	6,387	765	827	720	690	678	739
Electricity purchased	million kwh	408	602	859	888	955	989	1,101	1,265
	$000	7,559	7,877	16,514	17,064	15,798	16,126	17,662	20,244
Value of fuel and electricity used by small establishments[2]	$000	–	–	–	–	–	–	–	–
Total cost of fuel and electricity	$000	13,530	14,264	17,279	17,891	16,518	16,816	18,340	20,983
Electricity generated for own use and for sale	million kwh	35	47	30	34	37	–	–	–
Total Mining Industry									
Fuel	$000	30,909	33,866	29,290	35,304	38,168	42,986	48,466	47,602
Electricity purchased	million kwh	4,484	5,174	6,050	7,360	7,488	8,416	9,412	9,811
	$000	37,976	41,020	52,225	60,292	59,913	64,005	70,811	78,974
Value of fuel and electricity used by small establishments[2]	$000	–	–	762	797	786	572	363	423
Total cost of fuel and electricity	$000	68,885	74,886	82,277	96,393	98,867	107,563	119,640	126,999
Electricity generated for own use and for sale	million kwh	668	547	511	558	633	661	622	647

[1]See footnote Table 31. Industry coverage is the same as in Tables 27, 29 and 31. [2]Value of fuel and electricity used by small establishments which have reported in total only, without detail.
– Nil.

Table 33. Canada, Consumption of Fuel and Electricity in the Mineral Manufacturing Industries[1], 1969

		Primary Metals Industries	Nonmetallic Mineral Products Industries	Petroleum and Coal Products Industries	Total
	(000)				
Coal and coke	st	1,162	540	...	1,702
	$	19,093	6,548	4	25,645
Gasoline	gal	3,537	17,318	420	21,275
	$	1,219	6,465	158	7,842
Fuel oil, kerosene, coal oil	gal	289,984	128,945	3,484	422,413
	$	24,244	12,724	388	37,356
Liquefied petroleum gas	gal	12,078	2,475	10	14,563
	$	1,569	532	2	2,103
Natural gas	Mcf	47,613	46,933	10,909	105,455
	$	21,476	20,270	3,200	44,946
Other fuels	$	1,584	771	1,698	4,053
Total fuels	$	69,185	47,310	5,450	121,945
	million				
Electricity purchased	kwh	15,370	3,182	1,980	20,532
	(000)	73,114	23,297	13,059	109,470
Total value, fuels and electricity purchased	$	142,299	70,607	18,509	231,415
Value of purchased fuels and electricity of small establishments[2]	$	202	1,231	13	1,446
Total value of fuels and electricity purchased, all reporting companies	$	142,501	71,838	18,522	232,861

[1]Industry coverage is the same as in Tables 28, 30 and 34. [2]Value of fuels and electricity used by small establishments which have reported in total only, without detail.
... Less than 1,000 units.

Table 34. Canada, Cost of Fuel and Electricity in the Mineral Manufacturing Industries[1], 1962-1969

		1962	1963	1964	1965	1966	1967	1968	1969
Primary metals									
Fuel	$000	47,260	49,838	58,010	67,121	71,129	71,133	73,938	69,185
Electricity purchased	million kwh	8,295	8,672	11,150	11,326	12,531	13,118	14,363	15,370
	$000	40,038	42,070	47,920	52,388	56,774	60,624	68,834	73,114
Cost of fuel and electricity for small establishments[2]	$000	427	420	373	384	326	199	171	202
Total cost of fuel and electricity	$000	87,725	92,328	106,303	119,893	128,229	131,956	142,943	142,501
Nonmetallic mineral products									
Fuel	$000	34,233	35,693	38,453	42,925	45,479	44,055	45,237	47,310
Electricity purchased	million kwh	2,339	2,332	2,584	2,885	3,265	2,987	3,118	3,182
	$000	15,732	15,145	16,340	18,397	20,791	19,962	21,566	23,297
Cost of fuel and electricity for small establishments[2]	$000	851	869	893	1,104	1,122	852	1,165	1,231
Total cost of fuel and electricity	$000	50,816	51,707	55,686	62,426	67,392	64,869	67,968	71,838
Petroleum and coal products									
Fuel	$000	2,341	2,677	2,828	2,738	3,213	2,980	5,294	5,450
Electricity purchased	million kwh	1,250	1,291	1,527	1,518	1,586	1,659	1,818	1,980
	$000	8,509	8,660	9,751	9,820	10,177	10,699	11,467	13,059
Cost of fuel and electricity for small establishments[2]	$000	–	–	–	18	9	15	7	13
Total cost of fuel and electricity	$000	10,850	11,337	12,579	12,576	13,399	13,694	16,768	18,522
Total mineral manufacturing industries									
Fuel	$000	83,834	88,208	99,291	112,784	119,821	118,168	124,469	121,945
Electricity purchased	million kwh	11,884	12,295	15,261	15,729	17,832	17,764	19,299	20,532
	$000	64,279	65,875	74,011	80,605	87,742	91,285	101,867	109,470
Cost of fuel and electricity for small establishments[2]	$000	1,278	1,289	1,266	1,506	1,457	1,066	1,343	1,446
Total cost of fuel and electricity	$000	149,391	155,372	174,568	194,895	209,020	210,519	227,679	232,861

[1]Industry coverage is the same as in Tables 28, 30 and 33. [2]Total cost of fuel and electricity purchased by small establishments; no detail reported.
– Nil.

Table 35. Canada, Employment, Salaries and Wages in the Mining Industry[1], 1962-1969

		1962	1963	1964	1965	1966	1967	1968	1969
Metals									
Employees		58,243	57,119	57,648	60,942	61,670	61,728	63,369	60,550
Salaries and wages	$000	306,004	310,108	321,605	356,855	385,143	429,383	474,772	479,251
Average annual salary and wage	$	5,254	5,429	5,579	5,856	6,245	6,956	7,492	7,914
Nonmetals									
Employees		16,922	17,347	17,771	18,364	18,734	18,856	19,509	20,014
Salaries and wages	$000	77,327	81,671	89,048	96,591	104,033	113,151	127,686	142,603
Average annual salary and wage	$	4,570	4,708	5,011	5,260	5,553	6,000	6,545	7,125
Fuels									
Employees		21,129	21,065	21,038	21,514	21,796	22,094	22,038	21,524
Salaries and wages	$000	115,023	117,037	120,074	128,655	140,404	158,143	169,995	182,986
Average annual salary and wage	$	5,444	5,556	5,707	5,980	6,442	7,158	7,714	8,501
Total Mining									
Employees		96,294	95,531	96,457	100,820	102,200	102,678	104,916	102,088
Salaries and wages	$000	498,354	508,816	530,727	582,101	629,580	700,677	772,453	804,839
Average annual salary and wage	$	5,175	5,326	5,502	5,774	6,160	6,824	7,363	7,883

[1] According to the revised Standard Industrial Classification. Does not include cement and lime manufacturing and clay products (domestic clays) manufacturing.

Table 36. Canada, Employment, Salaries and Wages in the Mining Industry[1], 1964-1969

		1964	1965	1966	1967	1968	1969
Metals							
Production and related workers		46,727	49,050	48,276	48,262	49,238	46,023
Salaries and wages	$000	244,549	269,457	284,477	317,978	350,321	341,495
Annual average salary and wage	$	5,234	5,494	5,893	6,589	7,115	7,420
Administrative and office workers		10,921	11,892	13,394	13,466	14,131	14,527
Salaries and wages	$000	77,056	87,398	100,666	111,405	124,451	137,756
Annual average salary and wage	$	7,056	7,349	7,516	8,273	8,807	9,482
Nonmetals							
Production and related workers		14,211	14,688	14,916	15,049	15,458	15,933
Salaries and wages	$000	67,134	72,352	77,984	84,756	94,850	107,622
Annual average salary and wage	$	4,724	4,926	5,228	5,632	6,135	6,754
Administrative and office workers		3,560	3,676	3,818	3,807	4,051	4,081
Salaries and wages	$000	21,914	24,239	26,049	28,395	32,836	34,980
Annual average salary and wage	$	6,156	6,594	6,823	7,459	8,106	8,573
Fuels							
Production and related workers		11,399	11,308	11,003	10,919	10,370	9,412
Salaries and wages	$000	53,083	54,922	57,035	62,756	64,832	64,591
Annual average salary and wage	$	4,657	4,857	5,184	5,747	6,252	6,862
Administrative and office workers		9,639	10,206	10,793	11,175	11,668	12,112
Salaries and wages	$000	66,991	73,733	83,369	95,387	105,163	118,395
Annual average salary and wage	$	6,950	7,224	7,724	8,536	9,013	9,775
Total Mining Industry							
Production and related workers		72,337	75,046	74,195	74,230	75,066	71,368
Salaries and wages	$000	364,766	396,731	419,496	465,490	510,003	513,708
Annual average salary and wage	$	5,043	5,286	5,654	6,271	6,794	7,197
Administrative and office workers		24,120	25,774	28,005	28,448	29,850	30,720
Salaries and wages	$000	165,961	185,370	210,084	235,187	262,450	291,131
Annual average salary and wage	$	6,881	7,192	7,502	8,267	8,792	9,477
Total all employees		96,457	100,820	102,200	102,678	104,916	102,088
Salaries and wages all employees	$000	530,727	582,101	629,580	700,677	772,453	804,839
Average annual salary and wage	$	5,502	5,774	6,160	6,824	7,363	7,883

[1] See footnote Table 35.

Table 37. Canada, Employment, Salaries and Wages in the Mineral Manufacturing Industries[1], 1964-1969

		1964	1965	1966	1967	1968	1969
Primary Metal Industries							
Production and related workers		77,770	83,443	87,748	86,784	86,237	83,564
Salaries and wages	$000	427,710	478,482	518,347	541,970	570,183	583,498
Annual average salaries and wages	$	5,550	5,734	5,907	6,245	6,612	6,982
Administrative and office workers		20,010	21,189	22,555	23,294	23,702	24,300
Salaries and wages	$000	133,866	148,752	169,686	185,800	202,683	219,807
Annual average salaries and wages	$	6,690	7,020	7,523	7,976	8,551	9,045
Nonmetallic Mineral Products Industries							
Production and related workers		35,598	38,246	39,561	37,467	37,796	38,109
Salaries and wages	$000	164,302	188,351	206,120	207,204	223,173	246,196
Annual average salaries and wages	$	4,615	4,925	5,210	5,569	5,919	6,460
Administrative and office workers		11,273	11,044	11,583	11,793	16,191	11,781
Salaries and wages	$000	64,890	66,970	73,851	79,464	106,557	94,243
Annual average salaries and wages	$	5,756	6,064	6,376	6,738	6,581	7,999
Petroleum and Coal Products Industries							
Production and related workers		7,168	6,825	6,832	6,839	6,876	6,590
Salaries and wages	$000	44,784	43,387	48,780	52,462	56,703	61,217
Annual average salaries and wages	$	6,248	6,357	7,140	7,671	8,247	9,289
Administrative and office workers		3,478	3,090	3,173	3,264	3,130	3,145
Salaries and wages	$000	24,884	25,472	26,540	28,287	29,422	32,134
Annual average salaries and wages	$	7,155	8,243	8,364	8,666	9,400	10,217
Total Mineral Manufacturing Industries							
Production and related workers		120,536	128,514	134,141	131,090	130,909	128,263
Salaries and wages	$000	636,796	710,220	773,247	801,636	850,059	890,911
Annual average salaries and wages	$	5,283	5,526	5,764	6,115	6,494	6,945
Administrative and office workers		34,761	35,323	37,311	38,351	43,023	39,226
Salaries and wages	$000	223,640	241,194	270,077	293,551	338,662	346,184
Annual average salaries and wages	$	6,434	6,828	7,239	7,654	7,872	8,825
Total all employees		155,297	163,837	171,452	169,441	173,932	167,489
Salaries and wages all employees	$000	860,436	591,414	1,043,324	1,095,187	1,188,721	1,237,095
Annual average salaries and wages	$	5,541	5,807	6,085	6,464	6,834	7,386

[1]See Table 28 for industries covered.

Table 38. Canada, Wage Earners, Surface, Underground and Mill, in the Mining Industry, 1966-1969

	1966	1967	1968	1969
Metals				
Surface	14,176	13,864	14,061	13,269
Underground	25,994	25,482	25,146	22,996
Mill	8,106	8,916	10,031	9,758
Total	48,276	48,262	49,238	46,023
Nonmetals				
Surface	8,713	8,310	7,575	7,381
Underground	1,094	1,382	1,483	1,817
Mill	5,109	5,357	6,400	6,735
Total	14,916	15,049	15,458	15,933
Fuels				
Surface	5,215	5,380	5,222	4,292
Underground	5,788	5,539	5,148	5,120
Total	11,003	10,919	10,370	9,412
Total Mining Industry				
Surface	28,104	27,554	26,858	24,942
Underground	32,876	32,403	31,777	29,933
Mill	13,215	14,273	16,431	16,493
Total	74,195	74,230	75,066	71,368

[1] See footnote Table 34 re coverage.

Table 39. Canada, Labour Costs in Relation to Tons Mined, Metal Mines, 1967-1969

Type of Metal Mines	Wage Earners	Total Wages	Average Annual Wage	Ore Mined	Annual Average Mined Per Wage Earner	Wage Cost Per Ton Mined
		($000)	($)	(000st)	(st)	($)
1969						
Auriferous quartz	6,947	39,112	5,630	9,048	1,302	4.32
Copper-gold-silver	10,627	73,721	6,937	33,847	3,185	2.18
Nickel-copper	12,425	94,999	7,646	22,244	1,790	4.27
Silver-cobalt	430	2,599	6,044	286	665	9.09
Silver-lead-zinc	4,772	34,191	7,164	14,192	2,974	2.41
Iron ore	7,058	66,960	9,487	88,142	12,488	0.76
Miscellaneous metals	3,752	29,876	7,962	21,819	5,815	1.37
Total	46,011	341,458	7,421	189,578	4,120	1.80
1968						
Auriferous quartz	7,616[r]	40,493[r]	5,316[r]	9,269	1,217[r]	4.37[r]
Copper-gold-silver	10,423[r]	69,420[r]	6,660[r]	34,909	3,349[r]	1.99
Nickel-copper	14,980	115,264	7,695	29,651	1,979	3.88[r]
Silver-cobalt	470[r]	2,675[r]	5,691[r]	269	572[r]	9.94[r]
Silver-lead-zinc	4,645	30,994	6,673	12,503	2,691[r]	2.47[r]
Iron ore	7,830[r]	68,179[r]	8,707[r]	101,753	12,995[r]	0.67[r]
Miscellaneous metals	3,256[r]	23,197[r]	7,124[r]	17,702	5,436[r]	1.31
Total	49,220[r]	350,222[r]	7,115[r]	206,056	4,186[r]	1.70[r]
1967						
Auriferous quartz	8,683	43,674	5,030	10,290	1,185	4.25
Copper-gold-silver	10,776	65,660	6,093	31,279	2,903	2.10
Nickel-copper	13,699	98,137	7,163	24,796	1,810	3.96
Silver-cobalt	438	2,141	4,888	226	516	9.48
Silver-lead-zinc	4,441	27,536	6,200	11,663	2,626	2.36
Iron ore	7,001	58,312	8,329	90,165	12,878	0.65
Miscellaneous metals	3,209	22,442	6,993	18,118	5,646	1.24
Total	48,247	317,902	6,589	186,537	3,866	1.70

[r]Revised.

Table 40. Canada, Man-hours Paid, Production and Related Workers, Tons of Ore Mined and Rock Quarried in Metal Mines and Nonmetal Mining Operations, 1963-1969

		1963	1964	1965	1966	1967	1968	1969
Metal mines[1]								
Ore mined	million st	124.3	141.1	166.5	162.8	186.5	206.1	189.6
Man-hours paid[2]	million	99.7	100.7	106.4	101.4	103.8	105.2	95.8
Man-hours paid per ton mined	number	0.80	0.71	0.64	0.62	0.56	0.51	0.51
Tons mined per man-hour paid	st	1.25	1.40	1.56	1.61	1.80	1.96	1.98
Nonmetal mining operations[3]								
Ore mined and rock quarried	million st	119.0	132.9	144.0	171.3	177.9	173.4	179.9
Man-hours paid[2]	million	23.1	24.0	23.2	24.7	25.3	25.9	27.3
Man-hours paid per ton mined	number	0.19	0.18	0.16	0.14	0.14	0.15	0.15
Tons mined per man-hour paid	st	5.15	5.54	6.19	6.93	7.04	6.69	6.59

[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.

Table 41. Canada, Basic Wage Rates per Hour in Metal Mining Industry on October 1, 1970 and 1971p

	Gold Mining		Iron Mining		Other Metal Mines	
	1970	1971	1970	1971	1970	1971
	(dollars)					
Underground workers						
Cage and skiptenders	2.49	2.54	. .	. .	3.34	3.62
Chute blaster	2.42	2.52	. .	. .	3.43	3.77
Deckman	2.37	2.42	. .	. .	3.12	3.32
Hoistman	2.63	2.74	. .	. .	3.59	3.89
Labourer	2.42	2.51	. .	. .	3.15	3.39
Miner	2.49	2.56	. .	. .	3.36	3.61
Miner's helper	2.27	2.33	. .	. .	2.91	3.00
Motorman	2.39	2.39	. .	. .	3.25	3.54
Mucking machine operator	2.39	2.45	. .	. .	3.21	3.52
Mucker and trammer	2.31	2.38	. .	. .	3.23	3.49
Timberman	2.53	2.51	. .	. .	3.29	3.54
Trackman	2.38	2.41	. .	. .	3.31	3.50
Open-pit workers						
Blaster	. .	. .	3.49	3.76	. .	. .
Bulldozer operator	. .	. .	3.59	3.77	. .	. .
Driller machine	. .	. .	3.60	3.90	. .	. .
Dumptruck driver	. .	. .	3.75	3.89	. .	. .
Oiler	. .	. .	3.33	3.52	. .	. .
Shovel operator (power)	. .	. .	4.15	4.36	. .	. .
Surface and mill workers						
Blacksmith	. .	. .	. .	. .	3.54	3.76
Carpenter, maintenance	2.65	2.80	4.02	4.21	3.58	3.88
Crusher operator	2.34	2.51	3.47	3.68	3.25	3.56
Electrician	2.70	2.81	4.14	4.35	3.82	4.15
Filter operator	. .	. .	. .	. .	3.19	3.44
Flotation operator	. .	. .	. .	. .	3.40	3.65
Grinding-mill operator	. .	. .	3.57	3.80	3.31	3.64
Hoistman	. .	. .	. .	. .	. .	. .
Labourer	2.29	2.37	3.07	3.23	2.94	3.16
Machinist, maintenance	2.99	2.92	4.20	4.41	3.84	4.18
Mechanic, diesel	. .	. .	3.97	4.30	3.95	4.32
Mechanic, maintenance	2.53	2.66	4.03	4.20	3.76	4.02
Millman[1]	2.49	2.56	. .	. .	. .	. .
Pipefitter, maintenance	2.61	2.62	3.99	4.18	3.56	3.88
Solution man	. .	. .	. .	. .	3.16	3.54
Steel sharpener	2.53	2.56	. .	. .	3.27	3.76
Trademan's helper	2.55	2.65	3.30	3.53	3.18	3.36
Truck driver, light and heavy	2.30	2.41	3.50	3.70	3.38	3.71
Welder, maintenance	2.69	2.71	3.99	4.23	3.75	4.06
Millwright	. .	. .	4.00	4.30	3.84	4.02

[1]Includes filter operator, grinding mill operator (ball-mill operator, rod-mill operator, tubeman) and solution man.

pPreliminary; . . Not available or not applicable.

Table 42. Canada, Index Numbers of Average Wage Rates[1] by Industries 1966-1971 (base year 1961 = 100)

	1966	1967	1968	1969	1970	1971
Logging	140.2	156.0	162.5	179.8	192.8	212.3
Metal mining	122.7	130.2	138.9	146.2	159.4	169.9
Gold-quartz	134.6	142.7	154.5	161.6	171.3	179.5
Iron	121.0	129.0	133.2	147.1	158.1	166.0
Other metal	118.4	125.6	134.1	140.0	155.1	167.1
Manufacturing	121.6	130.5	140.6	151.2	162.9	176.3
Nondurable	121.9	131.0	141.4	152.5	163.2	176.9
Petroleum refineries	123.1	131.4	139.3	146.2	162.0	175.4
Durable	121.2	130.0	139.7	149.7	162.3	175.7
Primary metal industries	116.5	123.1	128.5	135.1	154.5	165.8
Metal fabricating industries	125.0	131.2	140.4	151.9	162.7	176.8
Machinery industries	122.7	131.0	140.5	151.8	163.3	173.0
Transportation equipment industries	122.5	131.7	142.1	152.8	164.2	179.5
Electrical products industries	112.3	123.4	133.8	141.7	151.0	163.4
Construction	129.8	142.0	154.9	167.0	195.5	223.7
Transportation, communication and other utilities	122.3	132.8	143.4	154.9	166.2	183.8
Trade	123.9	132.5	144.5	155.2	166.1	178.9
Service	125.5	133.9	141.8	154.0	166.4	178.0
Local government (municipal government only)	124.6	136.9	146.7	163.4	183.3	200.2
General Index all industries	124.0	133.4	143.8	155.1	167.8	182.3

[1]The weighted average of straight-time rates paid on a time basis in an occupation.

Table 43. Canada, Average Weekly Wages and Hours of Hourly Rated Employees in Mining, Manufacturing and Construction Industries, 1964-1971

	1964	1965	1966	1967	1968	1969	1970	1971p
Mining								
Average hours per week	42.2	42.5	42.3	41.9	41.8	41.4	41.0	40.4
Average weekly wage	97.43	103.30	110.29	119.09	128.28	135.94	152.10	163.22
Metals								
Average hours per week	41.7	41.9	41.6	41.3	41.2	40.7	40.3	39.3
Average weekly wage	99.48	105.76	112.99	112.79	131.55	137.68	154.68	163.88
Fuels								
Average hours per week	42.1	41.3	42.3	42.5	41.9	41.9	42.0	41.0
Average weekly wage	86.98	89.07	95.68	101.24	109.96	122.88	146.68	160.72
Nonmetals								
Average hours per week	41.7	42.7	42.1	42.3	42.4	41.9	41.3	41.4
Average weekly wage	94.42	99.49	104.00	112.35	121.24	129.05	139.21	151.52
Manufacturing								
Average hours per week	41.0	41.0	40.8	40.3	40.3	40.0	39.7	39.7
Average weekly wage	82.96	86.89	91.65	96.84	104.00	111.69	119.69	130.22
Construction								
Average hours per week	41.4	41.3	42.2	41.3	40.5	39.6	39.2	39.2
Average weekly wage	97.39	104.45	118.23	128.76	134.84	146.90	165.04	186.20

pPreliminary.

Table 44. Canada, Average Weekly Wages of Hourly Rated Employees in Mining Industry in Current and 1949 Dollars, 1964-1971

	1964	1965	1966	1967	1968	1969	1970r	1971p
Current Dollars								
All mining	97.43	103.30	110.29	119.09	128.28	135.94	152.10	163.22
Metals	99.48	105.76	112.99	122.79	131.55	137.68	154.68	163.88
Gold	80.27	84.71	91.12	95.72	101.26	107.69	113.72	128.48
Fuels	86.98	89.07	95.68	101.24	109.96	122.88	146.68	160.72
Coal	80.84	80.68	85.53	90.63	97.41	108.58	130.37	144.26
Nonmetals	94.42	99.49	104.00	112.35	121.24	129.05	139.21	151.52
1949 Dollars								
All mining	71.96	74.48	76.64	79.92	82.65	83.86	90.81	94.73
Metals	73.47	76.25	78.52	82.40	84.76	84.94	92.35	94.83
Gold	59.28	61.07	63.32	64.24	65.24	66.43	67.89	74.57
Fuels	64.24	64.22	66.49	67.94	70.85	75.81r	87.57	93.28
Coal	59.70	58.17	59.44	60.83	62.76	66.98	77.83	83.73
Nonmetals	69.73	71.73	72.27	75.40	78.12	79.61	83.11	87.94

pPreliminary; rRevised.

Table 45. Canada, Industrial Fatalities per Thousand Paid Workers in Main Industry Groups, 1961-1971

	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971P
Agriculture	0.10	0.09	0.08	0.11	0.08	0.10	0.05	0.05	0.06	0.03	0.04
Forestry	1.15	1.72	1.53	1.89	1.40	1.45	1.25	1.28	1.10	1.11	1.07
Fishing[1]	2.22	0.52	1.36	1.42	1.74	1.42	1.32	0.79	0.86	1.05	0.36
Mining[2]	1.69	1.86	2.26	1.85	1.31	1.21	1.61	1.15	1.40	0.96	0.95
Manufacturing	0.12	0.14	0.14	0.14	0.14	0.13	0.11	0.10	0.11	0.08	0.08
Construction	0.63	0.52	0.58	0.61	0.60	0.59	0.43	0.46	0.49	0.36	0.41
Transportation[3]	0.33	0.36	0.35	0.40	0.47	0.40	0.34	0.26	0.30	0.20	0.25
Trade	0.05	0.06	0.06	0.06	0.06	0.05	0.05	0.05	0.05	0.04	0.05
Finance[4]	0.01	0.01	0.01	0.01	0.01	0.00	0.02	–	0.01	0.01	0.08
Service[5]	0.02	0.01	0.02	0.04	0.03	0.03	0.03	0.02	0.03	0.02	0.02
Public Administration	0.19	0.22	0.29	0.14	0.13	0.07	0.08	0.14	0.14	0.13	0.13
Total	0.19	0.18	0.19	0.20	0.19	0.17	0.15	0.13	0.14	0.11[6]	0.12

[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. [6]Includes 7 fatalities in unspecified industries.
PPreliminary; – Nil.

Table 46. Canada, Strikes and Lockouts, 1970 and 1971

	1970			1971p		
	Strikes and Lockouts	Workers Involved	Duration in Man-Days	Strikes and Lockouts	Workers Involved	Duration in Man-days
Forestry	5	403	2,010	27	4,203	49,480
Fishing and trapping	–	–	–	1	4,500	40,500
Mines	15	6,876	53,680	19	7,680	193,490
Manufacturing	263	92,011	3,630,670	278	94,331	1,541,520
Construction	109	112,533	2,156,890	73	23,868	400,990
Transportation and utilities	48	35,502	379,990	54	45,764	254,270
Trade	42	2,214	46,220	46	4,857	81,040
Finance, insurance and real estate	–	–	–	1	227	1,140
Service	47	9,458	239,440	43	43,109	220,440
Public Administration	13	2,709	30,660	27	11,092	83,720
All industries	542	261,706	6,539,560	569	239,631	2,866,590

– Nil; pPreliminary.

Table 47. Canada, Ore Mined and Rock Quarried in the Mining Industry, 1967-1969

	1967	1968	1969
		(short tons)	
Metals			
Gold-quartz	10,289,826	9,268,857	9,048,327
Copper-gold-silver	31,279,288	34,909,280	33,847,436
Silver-cobalt	225,898	269,036	286,097
Silver-lead-zinc	11,662,803	12,503,061	14,191,584
Nickel-copper	24,795,565	29,650,613	22,243,976
Iron	90,165,071	101,753,446	88,142,291
Miscellaneous metals	18,118,195	17,702,304	21,818,907
Total	186,536,646	206,056,597	189,578,618
Nonmetals minerals			
Asbestos	77,502,293	78,115,612	88,438,106
Feldspar, nepheline syenite	588,330	662,046	791,053
Quartz (exclusive of sand)	1,264,397	1,101,805	1,268,446
Gypsum	5,302,119	5,914,312	6,625,859
Talc, soapstone	62,949	87,588	74,178
Rock salt	3,625,115	3,865,097	3,406,901
Other nonmetallics	9,221,764	11,598,754	15,257,175
Total	97,566,967	101,345,214	115,861,718
Structural materials			
Stone, all kinds quarried	84,007,308	75,939,767	67,477,012
Stone used to make cement	10,797,456	10,501,240	10,774,284
Stone used to make lime	3,269,092	2,531,850	2,981,494
Total	98,073,856	88,972,857	81,232,790
Total ore mined and rock quarried	382,177,469	396,374,668	386,673,126

Table 48. Canada, Ore Mined and Rock Quarried in the Mining Industry, 1935-1969

	Metals	Nonmetal[1]	Total
		(million short tons)	
1935	20.4	9.6	30.0
1936	22.7	13.0	35.7
1937	28.1	17.7	45.8
1938	31.4	14.9	46.3
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

[1]Includes nonmetallic mineral mining and all stone quarried, including stone used to make cement and lime. Coverage is the same as in Table 47.

Table 49. Canada, Exploration and Capital Expenditures in the Mining Industry[1] by Province 1969-1971

		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
		(millions of dollars)												
	1969	2.7	8.1	11.4	22.2	18.6	40.8	4.2	41.5	45.7	86.5	4.6	. .	. .
	1970	2.0	10.1	8.0	20.1	16.2	36.3	5.0	49.2	54.2	90.5	6.4	0.7	97.6
Atlantic provinces	1971P	. .	. .	. .	80.9	29.2	110.1	5.5	49.8	55.3	165.4	3.1	–	168.5
	1969	12.9	25.5	19.6	58.0	25.1	83.1	7.2	54.6	61.8	144.9	14.2	. .	. .
	1970	3.2	33.4	24.7	61.3	40.8	102.1	9.2	64.1	73.3	175.4	8.8	2.1	186.3
Quebec	1971P	5.4	32.3	156.2	193.9	55.4	249.3	8.7	69.7	78.4	327.7	11.4	2.8	341.9
	1969	9.6	51.1	16.3	77.0	50.2	127.2	21.0	76.0	97.0	224.2	22.6	. .	. .
	1970	10.7	70.8	42.6	124.1	79.6	203.7	17.5	118.4	135.9	339.6	32.2	0.5	372.3
Ontario	1971P	8.6	72.3	43.6	124.5	92.0	216.5	18.5	119.0	137.5	354.0	21.2	2.4	377.6
	1969	3.5	23.6	17.6	44.7	17.9	62.6	4.2	8.4	12.6	75.2	7.9	. .	. .
	1970	4.6	33.4	11.0	49.0	16.6	65.6	4.0	12.0	16.0	81.6	9.8	–	91.4
Manitoba	1971P	4.1	17.9	8.3	30.3	9.6	39.9	4.6	14.7	19.3	59.2	9.3	–	68.5
	1969	0.2	12.8	24.9	37.9	38.5	76.4	6.5	13.4	19.9	96.3	8.3	. .	. .
	1970	0.1	6.7	9.0	15.8	25.0	40.8	2.6	17.8	20.4	61.2	6.6	0.3	68.1
Saskatchewan	1971P	–	4.8	1.9	6.7	5.9	12.6	3.6	18.8	22.4	35.0	5.6	–	40.6
	1969	1.7	3.6	19.8	25.1	18.0	43.1	0.3	1.3	1.6	44.7	0.5	. .	. .
	1970	. .	. .	. .	18.5	17.8	36.3	0.5	7.7	8.2	44.5	2.5	0.1	47.1
Alberta	1971P	. .	. .	. .	8.4	7.4	15.8	0.4	6.3	6.7	22.5	4.2	0.5	27.2
	1969	5.2	32.7	88.7	126.6	37.0	163.6	2.5	23.1	25.6	189.2	28.4	. .	. .
	1970	3.1	60.8	69.6	133.5	63.2	196.7	3.7	42.0	45.7	242.4	37.4	0.9	280.7
British Columbia	1971P	3.8	32.6	173.3	209.7	138.9	348.6	3.6	53.8	57.4	406.0	26.2	1.3	433.5
	1969	2.1	7.7	21.9	31.7	6.8	38.5	0.6	8.0	8.6	47.1	12.3	. .	. .
	1970	2.0	11.9	7.3	21.2	7.0	28.2	1.2	8.9	10.1	38.3	15.1	0.4	53.8
Yukon and Northwest Territories	1971P	1.5	13.6	5.5	20.6	5.5	26.1	1.0	14.1	15.1	41.2	9.3	0.4	50.9
	1969	37.9	165.1	220.2	423.2	212.1	635.3	46.5	226.3	272.8	908.1	98.8	. .	. .
	1970	. .	. .	. .	443.5	266.2	709.7	43.7	320.1	363.8	1,073.5	118.8	5.0	1,197.3
Canada	1971P	26.1	194.6	454.3	675.0	343.9	1,018.9	45.9	346.2	392.1	1,411.0	90.3	7.4	1,508.7

[1]Excludes the petroleum and natural gas industries and the smelting and refining industries. Industry coverage is the same as in Table 50.
. . Not available for publication because of confidentiality; [P]Preliminary.

Table 50. Canada, Exploration and Capital Expenditures[1] in the Mining Industry by Type of Mining, 1969-1971

		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
		(millions of dollars)												
Metal mining														
Gold	1969	2.5	11.1	1.9	15.5	4.1	19.6	0.8	5.5	6.3	25.9	1.0	. .	. .
	1970	0.5	9.3	1.5	11.3	2.2	13.5	0.5	3.5	4.0	17.5	3.7	–	21.2
	1971P	0.4	6.8	2.2	9.4	2.4	11.8	0.5	3.9	4.4	16.2	1.2	–	17.4
Copper-gold-silver	1969	7.5	37.9	58.8	104.2	21.5	125.7	5.1	27.8	32.9	158.6	2.0	. .	. .
	1970	4.7	66.8	65.1	136.6	47.3	183.9	4.9	34.6	39.5	223.4	7.5	0.3	231.2
	1971P	5.2	52.2	156.0	213.4	127.7	341.1	4.9	43.7	48.6	389.7	3.4	0.5	393.6
Silver-lead-zinc	1969	3.2	12.8	23.3	39.3	13.5	52.8	1.4	11.8	13.2	66.0	1.5	. .	. .
	1970	2.9	10.0	3.2	16.1	6.5	22.6	1.6	12.5	14.1	36.7	3.5	0.2	40.4
	1971P	2.8	12.6	3.2	18.6	7.3	25.9	1.6	15.3	16.9	42.8	2.1	–	44.9
Uranium	1969	–	8.9	2.6	11.5	1.0	12.5	0.9	4.7	5.6	18.1	1.3	. .	. .
	1970	–	4.6	1.0	5.6	0.8	6.4	0.6	5.0	5.6	12.0	1.5	–	13.5
	1971P	–	3.8	0.3	4.1	1.9	6.0	1.3	4.2	5.5	11.5	1.8	–	13.3
Iron	1969	0.3	13.3	12.8	26.4	12.3	38.7	8.4	71.0	79.4	118.1	1.0	. .	. .
	1970	0.4	20.4	9.1	29.9	20.7	50.6	11.2	81.6	92.8	143.4	0.5	0.2	144.1
	1971P	(2)	(2)	(2)	(2)	31.1	(2)	11.1	85.3	96.4	(2)	0.6	–	. .
Other metal mining	1969	14.4	50.7	22.7	87.8	42.9	130.7	19.2	40.0	59.2	189.9	3.7	. .	. .
	1970	14.0	74.0	44.6	132.6	71.4	204.0	17.8	82.8	100.6	304.6	8.4	–	313.0
	1971P	12.5	94.8	235.0	342.3	69.0	411.3	19.1	88.8	107.9	646.7	6.8	0.2	653.7
Total metal mining	1969	27.9	134.7	122.1	284.7	95.3	380.0	35.8	160.8	196.6	576.6	10.5	. .	. .
	1970	22.5	185.1	124.5	332.1	148.9	481.0	36.6	220.0	256.6	737.6	25.1	. .	. .
	1971P	20.9	170.2	396.7	587.8	239.4	827.2	38.5	241.2	279.7	1,106.9	15.9	0.7	1,123.5
Nonmetal mining														
Asbestos	1969	1.3	7.0	4.7	13.0	15.8	28.8	1.3	27.0	28.3	57.1	0.4	. .	. .
	1970	1.1	10.6	18.2	29.9	29.7	59.6	1.7	31.3	33.0	92.6	0.3	1.8	94.7
	1971P	2.7	14.2	19.4	36.3	29.4	65.7	1.8	35.3	37.1	102.8	0.3	. .	. .
Potash and other nonmetal mining	1969	0.1	10.5	23.7	34.3	47.2	81.5	5.9	13.3	19.2	100.7	0.7	. .	. .
	1970	. .	. .	. .	15.0	29.5	44.5	2.4	19.2	21.6	66.1	0.5	0.6	67.2
	1971P	0.2	3.5	2.9	6.6	12.0	18.6	3.4	19.5	22.9	41.5	0.2	. .	. .

Table 50. (Concl.)

		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
		(millions of dollars)												
Nonmetal mining (Concl.)														
Miscellaneous nonmetal mining(3)	1969	3.0	9.6	68.3	80.9	50.9	131.8	3.5	24.8	28.3	160.1	0.1	. .	. .
	1970	. .	. .	. .	63.0	56.7	119.7	3.0	49.4	52.4	172.1	2.3	–	174.4
	1971P	1.5	5.2	35.1	41.8	62.7	104.5	2.2	50.1	52.3	156.8	2.9	. .	. .
Total nonmetal mining	1969	4.4	27.1	96.7	128.2	113.9	242.1	10.7	65.1	75.8	317.9	1.2	. .	. .
	1970	. .	. .	. .	107.9	115.9	223.8	7.1	99.9	107.0	330.8	3.1	2.4	336.3
	1971P	4.4	22.9	57.4	84.7	104.1	188.8	7.4	104.9	112.3	301.1	3.4	4.9	309.4
Metal and nonmetal mining exploration companies	1969	5.6	3.3	1.4	10.3	2.9	13.2	–	0.4	0.4	13.6	87.1	. .	. .
	1970	1.1	1.7	0.7	3.5	1.4	4.9	–	0.2	0.2	5.1	90.6	1.9	97.6
	1971P	0.8	1.5	0.2	2.5	0.4	2.9	–	0.1	0.1	3.0	71.0	1.8	75.8
Total mining	1969	37.9	165.1	220.2	423.2	212.1	635.3	46.5	226.3	272.8	908.1	98.8	. .	. .
	1970	. .	. .	. .	443.5	266.2	709.7	43.7	320.1	363.8	1,073.5	118.8	5.0	1,197.3
	1971P	26.1	194.6	454.3	675.0	343.9	1,018.9	45.9	346.2	392.1	1,411.0	90.3	7.4	1,508.7

[1] Excludes outlays in the petroleum and gas industries. [2] Data are confidential and are included under "other metal mining". Amounts shown under "iron ore" are totalled and included under the total for "other metal mining". [3] Includes coal mines, gypsum mines, salt mines and quarrying.
– Nil; . . Not available for publication due to confidentiality; P Preliminary.

Table 51. Canada, All Diamond Drilling on Metal Deposits by Mining Companies with Own Equipment and by Drilling Contractors, 1956-1969

	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
			(feet)		
1956	2,239,502	4,889,428	1,311,282	1,257,977	9,698,189
1957	1,846,621	3,603,971	1,062,020	942,794	7,455,406
1958	1,794,164	3,028,302	977,009	941,503	6,740,978
1959	1,831,234	3,643,912	925,486	1,258,106	7,658,738
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

[1]Includes iron, titanium, uranium, molybdenum and other metal deposits.
Note: Nonproducing companies are not included since 1964.

Table 52. Canada, Exploration Diamond Drilling, Metal Deposits, 1956-1969

	By Mining Companies with Own Personnel and Equipment	By Diamond Drill Contractors	Total
	(ft)	(ft)	(ft)
1956	1,556,963	5,396,113	6,953,076
1957	1,175,526	4,046,336	5,221,862
1958	777,994	3,939,059	4,717,053
1959	786,701	4,485,109	5,271,810
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

Note: Nonproducing companies are not included since 1964.

Table 53. Canada, Diamond Drilling, Other than for Exploration, on Metal Deposits, by Companies with Own Equipment and by Drilling Contractors, 1956-1969

	By Mining Companies with Own Personnel and Equipment	By Diamond Drill Contractors	Total
	(ft)	(ft)	(ft)
1956	2,593,578	151,535	2,745,113
1957	1,721,535	512,009	2,233,544
1958	1,457,926	565,999	2,023,925
1959	1,603,618	783,310	2,386,928
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	1,446,095
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

Note: Nonproducing companies are not included since 1964.
The total footage drilled shown in Tables 52 and 53 equals the total footage drilled reported in Table 51.

Table 54. Canada, Contract Diamond Drilling Operations[1], 1958-1969

	Footage Drilled	Income from Drilling	Average No. of Employees	Total Salaries and Wages
	(ft)	($ million)		($ million)
1958	4,426,594	14.4	1,717	6.9
1959	5,435,971	17.9	1,902	8.0
1960	5,521,211	17.1	1,912	8.0
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[r]	38.7	2,985	18.8
1969	7,766,957	44.8	3,109	21.3

[1]Includes contract diamond drilling in mining and in other industries.
[r]Revised.

Table 59. Crude Minerals[1] Transported through

	St. Lawrence		Welland	
	1969	1970	1969	1970
	(short tons)			
Metallic minerals				
Alumina and bauxite ore	132,841	137,161	132,841	137,161
Iron ore and conc.	11,643,029	15,114,277	13,553,532	16,041,560
Manganese ore	269,748	208,498	269,748	208,498
Nickel-copper ores and conc.	4,865	3,011	85	72
Titanium ore	42,750	66,099	44,542	66,099
Ores and conc., nes	52,726	94,597	51,773	88,209
Copper ores and conc.	9,321	6,763	9,321	6,763
Total metallic minerals	12,155,280	15,630,406	14,061,842	16,548,362
Nonmetallic minerals (incl., structural)				
Asbestos	11	5	11	5
Bentonite	142,671	171,382	146,671	177,377
China clay	42,581	44,622	40,628	44,612
Clay materials, nes	52,301	83,167	61,589	94,750
Sand and gravel	35,599	17,346	260,157	175,956
Crushed stone	30	3	30	3
Stone, crude, nes	75,548	12,908	97,752	19,423
Barites, natural	33	36	–	–
Fluorspar	236,601	166,393	196,968	126,696
Gypsum	80,749	79,819	725	424
Phosphate rock	17,495	16,025	–	–
Salt	387,676	466,234	811,836	1,067,658
Crude nonmetallic minerals, nes	15,702	12,618	6,056	5,102
Limestone	18	129	11,194	14,043
Potash	–	–	–	–
Dolomite	5,449	–	1,167,696	951,839
Sulphur in ores, crude or refined	–	–	–	–
Total nonmetallic minerals	1,092,464	1,070,687	2,801,313	2,677,888
Mineral fuels				
Petroleum crude	88,348	81,094	15,529	–
Natural gas	3,240	34,161	3,240	20,828
Coal, bituminous	640,230	328,678	10,774,409	10,772,203
Coal, nes	340	105	340	105
Total mineral fuels	732,158	444,038	10,793,518	10,793,136
Total crude minerals	13,979,902	17,145,131	27,656,673	30,019,386
Grand total all products	41,067,366	51,196,586	53,573,300	62,965,510
% crude minerals of grand total	34.0	33.5	51.6	47.7

[1] Domestic and imported in upbound and downbound traffic.
–Nil; nes Not elsewhere specified; [r]Revised.

Canadian Canals, 1969-1970

Sault Ste. Marie		Canso		Other Canals		Total	
1969	1970	1969	1970	1969	1970	1969r	1970
			(short tons)				
–	–	–	–	–	–	265,682	274,322
2,240	–	–	–	–	–	25,198,801	31,155,837
–	–	–	–	–	–	539,496	416,996
–	–	–	–	–	–	4,950	3,083
–	–	–	–	–	–	87,292	132,198
–	–	–	4,643	–	–	104,499	187,449
–	–	–	–	–	–	18,642	13,526
2,240	–	–	4,643	–	–	26,219,362	32,183,411
–	–	5,775	–	–	–	5,797	10
–	–	–	–	–	–	289,342	348,759
–	–	–	–	–	–	83,209	89,234
–	–	–	–	–	–	113,890	177,917
88,850	96,550	2,695	–	–	–	387,301	289,852
–	–	–	–	–	–	60	6
358	–	–	6,408	–	–	173,658	38,739
–	–	–	–	–	–	33	36
–	–	27,070	27,628	–	–	460,639	320,717
–	–	12,622	4,216	–	–	94,096	84,459
–	–	5,636	15,279	–	–	23,131	31,304
26,400	16,109	–	69,612	–	–	1,225,912	1,619,613
–	–	–	–	–	–	21,758	17,720
3,511	3,395	–	–	–	–	14,723	17,567
–	–	–	4,300	–	–	–	4,300
–	–	–	–	–	–	1,173,145	951,839
–	–	4,088	3,601	–	–	4,088	3,601
119,119	116,054	57,888	131,044	–	–	4,070,782	3,995,673
–	–	–	–	–	–	103,877	81,094
–	–	–	–	–	–	6,480	54,989
17,000	–	–	–	–	–	11,431,639	11,100,881
–	–	–	–	–	–	680	210
17,000	–	–	–	–	–	11,542,676	11,237,174
138,359	116,054	57,886	135,687	–	–	41,832,820	47,416,258
1,427,841	1,352,016	1,266,138	1,469,415	22,589	14,899	97,357,234	116,998,426
9.7	8.6	4.6	9.2	–	–	43.0	40.5

Table 60. Fabricated Mineral Products Transported through

	St. Lawrence		Welland	
	1969	1970	1969	1970
Metallic mineral products				
Ferroalloys	53,262	47,138	51,135	42,863
Pig iron	260,519	321,525	250,312	308,169
Primary iron and steel, nes	196,241	438,735	200,751	436,588
Castings forgings	39,342	50,028	25,870	31,810
Bars and rods, steel	445,741	432,080	402,948	358,890
Plate and sheet, steel	2,670,416	2,827,706	2,587,053	2,666,557
Structural shapes	940,063	621,429	829,716	581,215
Rails and track material	9,759	2,445	8,773	2,378
Pipe and tube iron and steel	108,611	101,660	89,608	88,874
Wire	135,396	128,208	117,781	116,763
Aluminum	34,239	22,353	21,273	15,472
Copper and alloys	12,443	25,266	5,550	6,520
Lead and alloys	6,719	6,235	6,391	5,931
Nickel and alloys	9,141	7,545	6,898	3,368
Zinc and alloys	32,258	37,454	22,813	32,045
Nonferrous metals, nes	9,972	9,380	7,969	6,003
Metal fabricated basic products, nes	133,333	146,872	115,782	123,382
Total metallic mineral products	5,097,455	5,226,059	4,750,623	4,826,823
Nonmetallic mineral products				
Building brick, clay	57	498	57	115
Bricks, tiles, nes	15,393	12,524	8,596	6,951
Glass basic products	104,774	67,599	60,287	39,830
Asbestos basic products	1,070	588	660	539
Cement	14,851	45,893	175,713	444,986
Cement basic products	1,026	172	431	84
Nonmetallic basic products	51,937	37,824	35,772	24,243
Fertilizers	5,200	12,111	5,061	59,011
Total nonmetallic products	194,308	177,209	286,577	575,759
Mineral fuel products				
Gasoline	515,447	498,429	320,473	240,955
Fuel oil	2,453,920	3,167,673	1,164,960	1,442,958
Lubricating oils and greases	190,921	138,435	148,445	115,808
Asphalts road oils	12,208	19,610	14,326	20,631
Coal tar, pitch	26,842	23,501	139,040	118,548
Petroleum and coal products, nes	267,945	99,642	261,536	86,262
Coke	349,616	495,647	316,126	460,450
Total mineral fuel products	3,816,899	4,442,937	2,364,906	2,485,612
Total fabricated mineral products	9,108,662	9,846,205	7,402,106	7,888,194
Grand total all products	41,067,366	51,196,586	53,573,300	62,965,510
% fabricated minerals of grand total	22.2	19.2	13.8	12.5

[1] Domestic and imported in upbound and downbound traffic.
– Nil; nes Not elsewhere specified; [r]Revised.

Canadian Canals, 1969-1970

	Sault Ste. Marie		Canso		Other Canals		Total	
	1969	1970	1969	1970	1969	1970	1969[r]	1970
	–	5,249	–	–	–	–	104,397	95,250
	1,650	–	–	–	–	–	512,481	629,689
	8,107	219	–	–	–	–	405,099	875,542
	7,238	10,532	–	–	–	–	72,450	92,370
	2,582	366	–	–	–	–	851,271	791,336
	15,445	27,948	–	2,299	–	–	5,272,914	5,524,510
	5,618	7,090	2,000	3,512	671	–	1,778,068	1,213,246
	104	18	–	2,921	–	–	18,636	7,762
	–	–	200	950	–	–	198,419	191,484
	–	–	–	–	–	–	253,177	244,971
	–	–	–	3,700	–	–	55,512	41,525
	–	–	–	–	–	–	17,993	31,786
	–	–	–	–	–	–	13,110	12,166
	–	–	–	–	–	–	16,039	10,913
	–	–	–	–	–	–	55,071	69,499
	–	–	–	–	–	–	17,941	15,383
	–	–	1,562	100	–	–	250,677	270,354
	40,744	51,422	3,762	13,482	671	–	9,893,255	10,117,786
	–	–	–	–	–	–	114	613
	–	–	–	–	–	–	23,989	19,475
	–	–	–	–	–	–	165,061	107,429
	–	–	–	–	–	–	1,730	1,127
	–	–	85	6,500	–	–	190,649	497,379
	–	–	–	–	–	–	1,457	256
	–	–	–	–	–	–	87,709	62,067
	–	9,235	–	2,900	–	–	10,261	83,257
	–	9,235	85	9,400	–	–	480,970	771,603
	116,249	72,905	290,920	353,235	822	307	1,243,911	1,165,831
	198,956	227,086	518,997	569,383	94	370	4,336,927	5,407,470
	1,505	–	–	22,648	–	–	340,871	276,891
	–	–	–	–	–	–	26,534	40,241
	2,675	–	3,500	–	–	–	172,057	142,049
	39,858	17,845	21,397	7,777	–	–	590,736	211,526
	–	–	–	–	–	–	665,742	956,097
	359,243	317,836	834,814	953,043	916	677	7,376,778	8,200,105
	399,987	378,493	838,661	975,925	1,587	677	17,751,003	19,089,494
	1,427,841	1,352,016	1,266,138	1,469,415	22,589	14,899	97,357,234	116,998,426
	28.0	28.0	66.2	66.4	7.0	4.5	18.2	16.3

Table 61. Canada, Taxes[1] Paid to Federal, Provincial and Municipal Governments by Important Divisions of the Mineral Industry, 1968 and 1969

	1968				1969			
	Federal Income Tax[2]	Provincial Tax[3]	Municipal Tax[4]	Total	Federal Income Tax[2]	Provincial Tax[3]	Municipal Tax[4]	Total
	(thousands of dollars)							
Auriferous quartz mining	2,014	1,230	928	4,172	2,690	1,286	922	4,898
Copper-gold-silver mining, smelting and refining	25,827	22,937	3,292	52,056	26,400	25,398	3,414	55,212
Silver-lead-zinc mining, smelting and refining	7,865	4,606	2,999	15,470	10,481	6,053	4,129	20,663
Nickel-copper, mining smelting and refining	30,789	16,222	3,227	50,238	20,026	15,680	3,752	39,458
Iron mining	2,359	10,361	4,512	17,232	3,163	9,358	6,115	18,636
Miscellaneous metal mining	12	681[r]	750[r]	1,443[r]	498	1,635	961	3,094
Asbestos mining	9,971	8,051	1,884	19,906	14,313	8,839	2,901	26,053
Feldspar, quartz, nepheline syenite mining	26	47	31	104	67	175	42	284
Gypsum mining	289	258	308	855	647	327	397	1,371
Peat mining	92	62	104	258	95	73	124	292
Salt mining	–	1,287	336	1,623	–	1,558	355	1,913
Talc and soapstone mining	–	17	5	22	3	20	7	30
Stone quarries	1,140	470	510	2,120	1,423	567	554	2,544
Sand and gravel pits	831	616	463	1,910	1,122	706	421	2,249
Miscellaneous nonmetal mining	1,422	2,427	1,617	5,466	1,965	3,391	2,598	7,954
Total of sectors covered	82,637	69,272	20,966	172,875	82,893	75,066	26,692	184,651

[1]Taxes reported are actual payments made within the calendar year, and do not reflect annual tax assessments. [2]Includes tax on nonoperating revenue. [3]Includes mining tax, corporation income tax, acreage taxes and royalties. [4]Taxes based on property valuation.
– Nil; [r]Revised.

Table 62. Canada, Taxes[1] Paid by Six Important Divisions of the Mineral Industry, 1963-1969

	1963	1964	1965	1966	1967	1968	1969
	($ million)						
Auriferous quartz mining	6.5	5.2	4.4	5.2	4.9	4.2	4.9
Copper-gold-silver mining, smelting and refining	20.3	26.0	34.9	34.3	49.3	52.1	55.2
Silver-lead-zinc mining, smelting and refining	20.5	26.5	27.9	22.9	18.7	15.5	20.7
Nickel-copper mining, smelting and refining	35.9	47.8	77.7	70.7	44.9	50.2	39.5
Iron mining	11.0	6.1	11.6	15.0	13.0	17.2	18.6
Asbestos mining	18.6	20.3	22.5	26.3	26.2	19.9	26.0
Total	112.8	131.9	179.0	174.4	157.0	159.1	164.9

[1]See footnotes, Table 61.

Table 63. Canada, Federal[1] and Provincial Income Taxes Payable by Corporations in the Mining and Mineral Manufacturing Industries, 1969-1970

	1969			1970		
	Federal	Provincial	Total	Federal	Provincial	Total
	($ million)					
Mining						
Metal mining	54.5	14.3	68.8	90.0	24.4	114.4
Mineral fuels	22.1	5.5	27.6	26.5	6.7	33.2
Other mining	23.1	6.7	29.8	23.1	6.8	29.9
Total mining	99.7	26.5	126.2	139.6	37.9	177.5
Mineral manufacturing						
Primary metals	89.7	25.6	115.3	68.2	19.7	87.9
Nonmetallic minerals	29.7	8.8	38.5	27.6	8.4	36.0
Petroleum and coal products	37.8	10.4	48.2	56.2	15.9	72.1
Total mineral manufacturing	157.2	44.8	202.0	152.0	44.0	196.0
Total mining and mineral manufacturing	256.9	71.3	328.8	291.6	81.9	373.5
Total, all industries	2,289.9	723.7	3,013.6	2,202.0	708.6	2,910.6
% mining and minerals manufacturing of total, all industries	11.2	9.9	10.9	13.2	11.6	12.8

[1]Net amount of federal income tax payable (including Old Age Security Tax) on corporation taxable income.
[2]Provincial income tax payable by corporations on taxable income.

Table 64. Canada, Capital and Repair Expenditures in the Mining[1] and Mineral Manufacturing Industries, 1970 and 1971

	1970			1971p			1972f		
	Capital	Repair	Total	Capital	Repair	Total	Capital	Repair	Total
	($ million)								
Mining industry									
Metal mines									
Gold	13.6	4.1	17.7	11.8	4.6	16.4	9.0	4.3	13.3
Silver, lead, zinc	22.7	14.3	37.0	21.7	15.4	37.1	20.2	15.6	35.8
Iron	50.6	92.8	143.4	225.0	90.7	315.7	331.2	95.9	427.1
Other metal mines	399.0	145.6	544.6	553.8	157.6	711.4	454.8	155.1	609.9
Total metal mines	485.9	256.8	742.7	812.3	268.3	1,080.6	815.2	270.9	1,086.1
Nonmetal mines									
Quarries and sand pits	13.3	20.9	34.2	16.1	22.4	38.5	11.9	22.6	34.5
Other nonmetal mines[2]	210.5	86.1	296.6	143.7	78.5	222.2	96.7	85.6	182.3
Total nonmetal mines	223.8	107.0	330.8	159.8	100.9	260.7	108.6	108.2	216.8
Mineral fuels									
Petroleum and gas	638.8	116.0	754.8	733.2	121.1	854.3	734.6	125.8	860.4
Total mining industry	1,348.5	479.8	1,828.3	1,705.3	490.3	2,195.6	1,658.4	504.9	2,163.3
Mineral manufacturing									
Primary metal industries									
Iron and steel mills	207.9	178.6	386.5	186.7	195.8	382.5	176.4	212.2	388.6
Steel pipe and tube mills	10.2	11.9	22.1	11.9	10.7	22.6	10.3	8.8	19.1
Iron foundries	11.2	11.9	23.1	11.0	11.1	22.1	10.4	12.5	22.9
Smelting and refining	169.3	138.4	307.7	170.5	135.3	305.8	167.2	137.6	304.8
Aluminum, rolling, casting and extruding	20.1	5.6	25.7	8.4	5.6	14.0	11.2	8.0	19.2
Copper and alloy rolling, casting and extruding	3.0	4.7	7.7	2.1	4.6	6.7	4.7	5.1	9.8
Other primary metal industries	3.5	2.1	5.6	2.2	2.6	4.8	3.4	2.8	6.2
Total primary metal industries	425.2	353.2	778.4	392.8	365.7	758.5	383.6	387.0	770.6
Nonmetallic mineral products									
Cement	14.6	15.3	29.9	17.4	16.6	34.0	61.9	16.9	78.8
Lime	7.2	1.5	8.7	4.5	1.8	6.3	2.4	1.8	4.2
Gypsum products	6.7	2.1	8.8	2.5	1.4	3.9	3.3	1.7	5.0
Concrete products and ready-mix	32.7	37.5	70.2	33.0	34.5	67.5	32.6	34.5	67.1
Clay products	7.7	5.3	13.0	4.7	4.1	8.8	5.6	4.2	9.8
Refractories	1.7	1.3	3.0	1.8	1.8	3.6	1.4	1.9	3.3
Asbestos	0.8	2.4	3.2	2.2	2.4	4.6	2.7	2.5	5.2

Table 64. (Concl.)

	1970			1971p			1972f		
	Capital	Repair	Total	Capital	Repair	Total	Capital	Repair	Total
	($ million)								
Mineral manufacturing (cont.)									
Glass and glass products	58.7	8.0	66.7	20.9	5.1	26.0	21.5	5.4	26.9
Abrasives	2.7	5.6	8.3	2.6	4.5	7.1	2.6	4.4	7.0
Other nonmetallic mineral products	2.2	3.5	5.7	2.0	4.3	6.3	4.1	4.7	8.8
Total nonmetallic mineral products	135.0	82.5	217.5	91.6	76.5	168.1	138.1	78.0	216.1
Petroleum and coal products	231.1	60.2	291.3	224.8	64.3	289.1	281.8	76.1	357.9
Total mineral manufacturing industries	791.3	495.9	1,287.2	709.2	506.5	1,215.7	803.5	541.1	1,344.6
Total mining and mineral manufacturing industries	2,139.8	975.7	3,115.5	2,414.5	996.8	3,411.3	2,461.9	1,046.0	3,507.9

[1]Does not include cement, lime and clay products (domestic clays), manufacturing, smelting and refining. [2]Includes coal mines, asbestos, gypsum, salt and miscellaneous nonmetals.
[p] Preliminary; [f] Forecast intentions.

Table 65. Canada, Capital and Repair Expenditure in the Mining Industry[1], 1962-1972

	1962	1963	1964[r]	1965	1966[r]	1967	1968	1969	1970	1971[p]	1972[f]
						($ million)					
Metal mines											
Capital											
Construction	137.8	118.3	147.0	121.4	209.9	238.1	264.8	295.1	335.6	579.6	502.2
Machinery	71.2	71.6	92.8	79.2	138.5	131.3	105.2	98.2	150.3	232.7	313.0
Total	209.0	189.9	239.8	200.6	348.4	369.4	370.0	393.3	485.9	812.3	815.2
Repair											
Construction	14.0	15.8	17.7	21.9	25.1	33.4	47.9	35.7	36.6	34.3	33.6
Machinery	64.5	76.3	84.4	100.5	115.9	116.6	152.2	160.9	220.2	234.0	237.3
Total	78.5	92.1	102.1	122.4	141.0	150.0	200.1	196.6	256.8	268.3	270.9
Total capital and repair	287.5	282.0	341.9	323.0	489.4	519.4	570.1	589.9	742.7	1,080.6	1,086.1
Nonmetal mines											
Capital											
Construction	24.7	18.7	36.7	58.1	106.7	121.1	110.2	128.1	107.9	65.4	45.6
Machinery	35.5	40.8	45.0	34.8	68.9	85.4	128.4	113.9	115.9	94.4	63.0
Total	60.2	59.5	81.7	92.9	175.6	206.5	238.6	242.0	223.8	159.8	108.6
Repair											
Construction	3.3	3.6	3.2	3.7	3.4	4.5	4.3	10.4	7.1	5.8	5.8
Machinery	27.6	31.5	37.9	47.2	49.4	57.0	57.5	64.7	99.9	95.1	102.4
Total	30.9	35.1	41.1	50.9	52.8	61.5	61.8	75.1	107.0	100.9	108.2
Total capital and repair	91.1	94.6	122.8	143.8	228.4	268.0	300.4	317.1	330.8	260.7	216.8
Mineral fuels											
Capital											
Construction	176.8	234.3	270.6	419.2	450.0	403.0	407.4	465.3	552.6	646.1	677.0
Machinery	33.7	37.9	40.5	22.1	55.8	71.8	58.0	76.6	86.2	87.1	57.6
Total	210.5	272.2	311.1	441.3	505.8	474.8	465.4	541.9	638.8	733.2	734.6
Repair											
Construction	13.6	15.7	23.6	25.4	28.6	34.2	56.3	73.7	93.5	92.3	97.4
Machinery	12.3	13.9	10.8	24.0	21.3	14.7	19.2	19.0	22.5	28.8	28.4
Total	25.9	29.6	34.4	34.4	49.9	48.9	75.5	92.7	116.0	121.1	125.8
Total capital and repair	236.4	301.8	345.5	490.7	555.7	523.7	540.9	634.6	754.8	854.3	860.4

Table 65. (Concl.)

	1962	1963	1964[r]	1965	1966[r]	1967	1968	1969	1970	1971[p]	1972[f]
	($ million)										
Total mining											
Capital											
Construction	339.3	371.3	454.3	598.7	766.6	762.2	782.4	888.5	996.1	1,291.1	1,224.8
Machinery	140.4	150.3	178.3	136.1	263.2	288.5	291.6	288.7	352.4	414.2	433.6
Total	479.7	521.6	632.6	734.8	1,029.8	1,050.7	1,074.0	1,177.2	1,348.5	1,705.3	1,658.4
Repair											
Construction	30.9	35.1	44.5	51.0	57.1	72.1	108.5	119.8	137.2	132.4	136.8
Machinery	104.4	121.7	133.1	171.7	186.6	188.3	228.9	244.6	342.6	357.9	368.1
Total	135.3	156.8	177.6	222.7	243.7	260.4	337.4	364.4	479.8	490.3	504.9
Total capital and repair	615.0	678.4	810.2	957.5	1,273.5	1,311.1	1,411.4	1,541.6	1,828.3	2,195.6	2,163.3

[1] Does not include cement, lime and clay products (domestic clays) manufacturing, and smelting and refining. [2] Includes coal mines, asbestos, gypsum, salt, miscellaneous nonmetals, quarrying, and sand pits.
[p] Preliminary estimates of intentions; [f] Forecast intentions, [r] Revised.

Table 66. Canada, Capital and Repair Expenditures in the Mineral Manufacturing Industries[1], 1961-1972

	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971p	1972f
	($ million)										
Primary metal industries[2]											
Capital											
Construction	58.4	44.4	58.4	61.6	85.2	82.0	77.5	71.5	114.0	87.9	74.1
Machinery	159.1	136.8	214.4	202.9	300.7	202.8	157.9	221.4	311.2	304.9	309.5
Total	217.5	181.2	272.8	264.5	385.9	284.8	235.4	292.9	425.2	392.8	383.6
Repair											
Construction	18.5	16.6	18.0	18.5	21.8	24.9	27.7	22.6	28.6	26.9	29.2
Machinery	151.9	166.1	194.4	215.0	253.4	258.1	281.4	267.9	324.6	338.8	357.8
Total	170.4	182.7	212.4	233.5	275.2	283.0	309.1	290.5	353.2	365.7	387.0
Total capital and repair	387.9	363.9	485.2	498.0	661.1	567.8	544.5	583.4	778.4	758.5	770.6
Nonmetallic mineral products[3]											
Capital											
Construction	13.7	13.8	20.1	30.0	50.9	39.5	19.6	37.1	30.7	21.9	27.9
Machinery	38.4	38.9	61.9	78.3	108.6	80.3	66.5	84.0	104.3	69.7	110.2
Total	52.1	52.7	82.0	108.3	159.5	119.8	86.1	121.1	135.0	91.6	138.1
Repair											
Construction	5.2	5.5	5.4	6.4	7.2	9.3	7.2	7.2	5.4	6.8	6.7
Machinery	51.3	52.8	58.3	66.1	72.1	63.9	73.8	72.1	77.1	69.7	71.3
Total	56.5	58.3	63.7	72.5	79.3	73.2	81.0	79.3	82.5	76.5	78.0
Total capital and repair	108.6	111.0	145.7	180.8	238.8	193.0	167.1	200.4	217.5	168.1	216.1
Petroleum and coal products											
Capital											
Construction	56.7	38.0	20.4	30.3	55.5	78.8	99.0	116.9	213.7	195.2	262.6
Machinery	8.9	8.6	4.3	10.3	9.6	21.4	28.8	12.9	17.4	29.6	19.2
Total	65.6	46.6	24.7	40.6	65.1	100.2	127.8	129.8	231.1	224.8	281.8
Repair											
Construction	28.1	30.0	32.3	29.5	32.6	36.0	46.6	52.1	51.0	55.6	66.0
Machinery	4.9	5.2	5.9	7.0	9.1	10.2	8.6	6.8	9.2	8.7	10.1
Total	33.0	35.2	38.2	36.5	41.7	46.2	55.2	58.9	60.2	64.3	76.1
Total capital and repair	98.6	81.8	62.9	77.1	106.8	146.4	183.0	188.7	291.3	289.1	357.9

Table 66. (Concl.)

	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971p	1972f
	($ million)										
Total mineral manufacturing industries											
Capital											
Construction	128.8	96.2	98.9	121.9	191.6	200.3	196.1	225.5	358.4	305.0	364.6
Machinery	206.4	184.3	280.6	291.5	418.9	304.5	253.2	318.3	432.9	404.2	438.9
Total	335.2	280.5	379.5	413.4	610.5	504.8	449.3	543.8	791.3	709.2	803.5
Repair											
Construction	51.8	52.1	55.7	54.4	61.6	70.2	81.5	81.9	85.0	89.3	101.9
Machinery	208.1	224.1	258.6	288.1	334.6	332.2	363.8	346.8	410.9	417.2	439.2
Total	259.9	276.2	314.3	342.5	396.2	402.4	445.3	428.7	495.9	506.5	541.1
Total capital and repair	595.1	556.7	693.8	755.9	1,006.7	907.2	894.6	972.5	1,287.2	1,215.7	1,344.6

[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 estimates of intentions; [f]Forecast intentions.

Table 67. Canada, Capital Expenditures in the Petroleum and Natural Gas and Allied Industries[1], 1961-1972

	Petroleum and Natural Gas Extraction[2]	Transportation, including Rail, Water and Pipelines	Marketing (chiefly outlets of oil companies)	Natural Gas Distribution	Petroleum Refining, Including Lubricants	Natural Gas Processing Plants	Total Capital Expenditures
	($ million)						
1961	272.0	164.9	56.0	59.3	31.2	76.5	659.9
1962	268.9	72.2	47.7	69.3	64.8	21.9	544.8
1963	297.1	107.9	53.0	84.1	44.2	38.6	624.9
1964	336.7	164.0	48.3	68.3	23.9	40.6	681.8
1965	381.0	112.1	55.2	72.5	39.8	41.5	702.1
1966	453.5	154.0	64.0	92.3	64.8	50.1	878.7
1967	385.1	204.9	86.8	76.4	99.6	89.7	942.5
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	128.9	103.8	1,112.0
1970	449.3	246.1	100.0	100.4	229.8	189.5	1,315.1
1971p	474.1	372.0	94.9	113.3	220.5	259.1	1,533.9
1972f	487.9	445.0	113.0	118.7	277.2	146.7	1,688.5

[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 back to 1961. Does not include expenditures for geological and geophysical operations. [p]Preliminary; [f]Forecast intentions.

Table 68. Canada, Financial Statistics of Corporations in the Mining Industry[1]

	Corporations		Assets	
		(%)	($ million)	(%)
Metal mines				
Reporting corporations				
50 per cent and over nonresident	61	22.4	3,408.1	55.5
Under 50 per cent nonresident	145	53.3	2,653.7	43.2
Government business enterprise	1	0.4	74.8	1.2
Other corporations	65	23.9	6.4	0.1
Total, all corporations	272	100.0	6,143.0	100.0
Mineral fuels				
Reporting corporations				
50 per cent and over nonresident	228	31.8	4,699.6	82.5
Under 50 per cent nonresident	180	25.1	975.4	17.1
Government business enterprise	–	–	–	–
Other corporations	310	43.1	24.4	0.4
Total, all corporations	718	100.0	5,699.4	100.0
Other mining (including Mining Services)				
Reporting Corporations				
50 per cent and over nonresident	187	6.9	1,506.1	57.0
Under 50 per cent nonresident	883	32.4	968.4	36.7
Government business enterprise	2	–	8.8	0.3
Other corporations	1,651	60.7	158.2	6.0
Total, all corporations	2,723	100.0	2,641.5	100.0
Total mining				
Reporting corporations				
50 per cent and over nonresident	476	12.8	9,613.8	66.4
Under 50 per cent nonresident	1,208	32.6	4,597.5	31.7
Government business enterprise	3	–	83.6	0.6
Other corporations	2,026	54.6	189.0	1.3
Total, all corporations	3,713	100.0	14,483.9	100.0

[1]Classification of the industry is the same as in Table 27.
Note: Footnotes for Table 69 apply to this table.
– Nil; . . Not available; – Amount too small to be expressed.

by Degree of Nonresident Ownership, 1969

Equity		Sales		Profits		Taxable Income	
($ million)	(%)	($ million)	(%)	($ million)	(%)	($ million)	(%)
2,012.6	49.8	1,436.1	55.0	315.3	47.9	40.7	37.0
1,975.1	48.8	1,161.6	44.4	343.8	52.3	70.5	64.2
51.0	1.3	16.2	0.6	−1.2	−0.2	..	..
4.6	0.1	0.4	–	−0.2	–	..	..
4,043.3	100.0	2,614.3	100.0	657.7	100.0	109.9	100.0
3,024.1	82.8	1,296.1	90.6	309.3	90.2	7.9	183.7
621.7	17.0	123.9	8.7	33.7	9.9	−3.2	−74.4
–	–	–	–	–	–	–	–
8.4	0.2	10.4	0.7	−0.2	−0.1	−0.4	−9.3
3,654.2	100.0	1,430.4	100.0	342.8	100.0	4.3	100.0
838.3	53.2	574.7	59.8	74.3	82.9	13.3	369.4
648.9	41.2	309.6	32.2	27.9	31.1	−0.9	−25.0
5.9	0.4	3.5	0.4	1.0	1.1	–	–
81.1	5.2	72.7	7.6	−13.5	−15.1	−8.8	−244.4
1,574.2	100.0	960.5	100.0	89.7	100.0	3.6	100.0
5,875.0	63.4	3,306.9	66.1	698.9	64.1	61.9	52.6
3,245.7	35.0	1,595.1	31.8	405.4	37.2	66.4	56.3
56.9	0.6	19.7	0.4	−0.2	–	..	..
94.1	1.0	83.5	1.7	−13.9	−1.3	..	..
9,271.7	100.0	5,005.2	100.0	1,090.2	100.0	117.8	100.0

Table 69. Canada, Financial Statistics of Corporations in the Mineral Manufacturing Industries[1]

	Corporations[2]		Assets[5]	
		(%)	($ million)	(%)
Primary metal products				
Reporting corporations[2]				
50 per cent and over nonresident	62	14.0	1,900.8	43.6
Under 50 per cent nonresident	143	32.2	2,251.6	51.7
Government business enterprises[3]	3	0.6	183.4	4.2
Other[4]	236	53.2	22.7	0.5
Total all corporations	444	100.0	4,358.5	100.0
Nonmetallic mineral products				
Reporting corporations[2]				
50 per cent and over nonresident	84	8.9	884.8	52.1
Under 50 per cent nonresident	341	36.3	736.9	43.4
Government business enterprises[3]	2	0.2	. .	. .
Other[4]	513	54.6	. .	. .
Total all corporations	940	100.0	1,698.8	100.0
Petroleum and Coal products				
Reporting corporations[2]				
50 per cent and over nonresident	23	41.8	4,835.2	99.5
Under 50 per cent nonresident	11	20.0	22.9	0.5
Government business enterprises[3]	–	–	–	–
Other[4]	21	38.2	2.1	– –
Total all corporations	55	100.0	4,860.2	100.0
Total Mineral Manufacturing Industries				
Reporting companies[2]				
50 per cent and over nonresident	169	11.8	7,620.8	
Under 50 per cent nonresident	495	34.4	3,011.4	
Government business enterprises[3]	5	0.3	. .	
Other[4]	770	53.5	. .	
Total all corporations	1,439	100.0	10,917.5	

[1]Classification of industries is the same as in Table 28.
[2]Corporations reporting under the Corporations and Labour Unions Returns Act. (a) 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. (b) Each corporation is classified according to the percentage of its voting rights which are owned by nonresidents, either directly or through other Canadian corporations, and the whole of the corporation is assigned to this particular degree of *foreign ownership.*
[3]Nontaxable 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 nonprofit 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.

by Degree of Nonresident Ownership, 1969

Equity[6]		Sales[7]		Profits[8]		Taxable Income[9]	
($ million)	(%)	($ million)	(%)	($ million)	(%)	($ million)	(%)
912.0	42.2	1,373.7	43.4	156.9	52.9	112.6	54.9
1,149.5	53.3	1,582.2	49.9	134.6	45.3	91.1	44.5
89.0	4.1	172.0	5.4	4.1	1.4	–	–
8.4	0.4	40.1	1.3	1.2	0.4	1.2	0.6
2,158.9	100.0	3,168.0	100.0	296.8	100.0	204.9	100.0
469.6	57.8	654.4	45.7	64.0	55.5	34.8	54.5
317.2	39.0	683.5	47.8	50.7	44.0	29.4	46.0
. .	. .	. .	. .	. .	. .	. .	. .
. .	. .	. .	. .	. .	. .	. .	. .
813.1	100.0	1,430.8	100.0	115.3	100.0	63.9	100.0
3,035.2	99.6	3,904.7	98.7	336.0	97.1	91.5	97.8
12.6	0.4	46.6	1.2	9.8	2.8	1.9	2.0
–	–	–	–	–	–	–	–
1.2	– –	3.2	0.1	0.2	0.1	0.2	0.2
3,049.0	100.0	3,954.5	100.0	346.0	100.0	93.6	100.0
4,416.8		6,021.8		556.9		238.9	
1,479.3		2,312.3		195.1		122.4	
. .		. .		. .		. .	
. .		. .		. .		. .	
6,021.0		8,553.3		758.1		362.4	

[6]This 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 nonfinancial corporations, sales are gross revenues from nonfinancial operations. For financial corporations sales include income from financial as well as nonfinancial 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]The 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; – – Amount too small to be expressed.
Source: *Annual Report of the Minister of Industry, Trade and Commerce* under the Corporations and Labour Unions Returns Act (Part 1 – Corporations).

Table 70. Canada, Financial Statistics of Corporations in Nonfinancial Industries

	Agriculture, Forestry, Fishing and Trapping		Mining		Manufacturing	
	1968	1969	1968	1969	1968	1969
Number of corporations						
Foreign control	75	81	470	501	2,179	2,344
Canadian control[1]	963	1,223	1,073	1,186	6,452	6,912
Other corporations	4,354	4,489	2,123	2,026	12,222	11,826
Total corporations	5,392	5,793	3,666	3,713	20,853	21,082
Assets			($ million)			
Foreign control	87.3	150.8	7,787.5	10,085.2	24,729.8	25,039.5
Canadian control[1]	595.5	703.4	3,788.8	4,209.7	16,605.9	17,905.2
Other corporations	398.2	430.1	177.9	189.0	1,093.2	1,046.9
Total corporations	1,081.0	1,284.3	11,754.2	14,483.9	42,428.9	43,991.6
Equity						
Foreign control	48.7	87.5	4,491.2	6,250.2	12,966.9	13,261.2
Canadian control[1]	233.4	238.0	2,653.3	2,927.4	7,894.5	8,279.0
Other corporations	95.7	107.9	91.7	94.1	400.0	352.4
Total corporations	377.8	433.4	7,236.2	9,271.7	21,261.4	21,892.6
Sales						
Foreign control	71.0	80.7	2,562.5	3,500.3	26,218.6	29,063.2
Canadian control[1]	442.8	531.6	1,369.3	1,421.4	19,530.5	21,193.6
Other corporations	340.8	366.7	88.4	83.5	1,955.7	1,894.2
Total corporations	854.6	979.0	4,020.2	5,005.2	47,704.8	52,151.0
Profits						
Foreign control	5.0	10.9	494.6	763.9	2,177.0	2,266.0
Canadian control	25.0	29.7	343.5	340.2	1,218.5	1,294.4
Other corporations	10.7	13.0	−7.8	−13.9	50.3	43.5
Total corporations	40.7	53.6	830.3	1,090.2	3,445.8	3,603.9
Taxable income						
Foreign control	3.4	1.4	56.1	64.9	1,460.3	1,563.3
Canadian control[1]	16.6	16.0	61.7	62.3	833.0	969.6
Other corporations	5.0	5.7	−6.6	−9.4	39.1	31.9
Total corporations	25.0	23.1	111.2	117.8	2,332.4	2,564.8

See footnotes bottom of Table 69.
[1]Includes both the private sector and government business enterprises.

by Major Industry Group and by Control, 1968 and 1969

Construction		Transportation, Communication and Other Utilities		Trade		Services		Total	
1968	1969	1968	1969	1968	1969	1968	1969	1968	1969
146	160	236	269	1,540	1,738	375	463	5,021	5,556
3,960	4,350	1,695	1,816	11,099	12,156	3,119	3,475	28,361	31,118
13,587	14,692	5,630	6,052	36,720	39,598	21,368	22,823	96,004	101,506
17,693	19,202	7,516	8,137	49,359	53,492	24,862	26,761	129,836	138,180
				($ million)					
762.8	730.0	2,575.3	2,824.7	4,410.3	4,817.7	1,019.5	1,369.6	41,372.5	45,017.5
3,529.6	4,186.8	31,092.7	33,633.8	10,694.3	11,909.0	2,549.2	2,962.1	68,856.0	75,510.0
930.2	1,056.9	397.6	427.1	2,494.8	2,804.8	1,282.6	1,434.9	6,774.5	7,389.7
5,222.6	5,973.7	34,065.6	36,885.6	17,599.4	19,531.5	4,851.3	5,766.6	117,003.0	127,917.2
157.9	169.3	968.8	1,052.5	1,638.5	1,811.4	454.1	560.6	20,726.1	23,192.7
920.9	1,014.5	10,378.0	10,931.5	3,803.0	4,110.2	799.2	1,016.3	26,682.3	28,516.9
311.1	342.4	113.5	138.2	938.3	1,028.4	425.4	462.0	2,375.7	2,525.4
1,389.9	1,526.2	11,460.3	12,122.2	6,379.8	6,950.0	1,678.7	2,038.9	49,784.1	54,235.0
939.2	1,078.6	1,069.4	1,176.2	9,670.4	9,842.5	749.1	913.3	41,280.2	45,654.8
5,520.2	5,665.1	7,954.4	8,752.2	25,991.6	27,986.1	2,174.5	2,425.8	62,983.3	67,975.8
1,803.9	1,953.2	518.4	584.4	5,393.6	6,008.7	1,687.2	1,862.4	11,788.0	12,753.1
8,263.3	8,696.9	9,542.2	10,512.8	41,055.6	43,837.3	4,610.8	5,201.5	116,051.5	126,383.7
39.8	51.6	168.3	162.5	331.9	323.0	93.0	97.8	3,309.6	3,675.7
196.8	175.8	822.2	754.4	953.2	1,006.9	113.0	139.8	3,672.2	3,741.2
67.4	70.9	15.7	20.3	156.0	167.3	89.8	95.2	382.1	396.3
304.0	298.3	1,006.2	937.2	1,441.1	1,497.2	295.8	332.8	7,363.9	7,813.2
38.9	41.8	96.2	105.1	299.3	286.4	70.0	73.5	2,024.2	2,136.4
124.1	102.0	244.1	217.2	501.6	525.7	76.7	90.9	1,857.8	1,983.7
56.9	58.0	12.5	16.7	141.0	148.4	71.2	76.1	319.1	327.4
219.9	201.8	352.8	339.0	941.9	960.5	217.9	240.5	4,201.1	4,447.5

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