MINERAL REPORT 18

CANADIAN MINERALS YEARBOOK 1968

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DEPARTMENT OF ENERGY, MINES AND RESOURCES
OTTAWA

1970

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Foreword

This issue of the Canadian Minerals Yearbook is a report of developments in the industry for 1968. The 55 chapters dealing with specific commodities were issued in advance under the title Preprints, Canadian Minerals Yearbook 1968 to provide information as soon as possible to interested persons. Chapter One, General Review, written specifically for the Yearbook each year, deals with the overall position of the industry in its national and international perspectives; it is supported by 66 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 1969

Editor: G.E. Thompson

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Readers wishing more recent information than that contained in the present volume should obtain the 1969 series of preprints: complete set available from the Queen's Printer, $5. Individual copies are available from the Distribution Office, Mineral Resources Branch, Department of Energy, Mines and Resources, Ottawa, at 25¢ each.

Frontispiece: GASPE COPPER MINES, LIMITED, Murdochville, Quebec. Copper Mountain open-pit mine, upper centre. Crusher building, middle right. Smelter, middle. Mill building, lower centre. Conveyor transfer house for Needle Mountain ore, lower right. (Photo by Hunter)

Contents

General Review

New estimates of Canada's Gross National Product (GNP) for the years 1926 to 1968 have been made possible by a comprehensive review of National Income and Expenditure Accounts carried out by the Dominion Bureau of Statistics. From these new statistics the average annual rate of increase in the GNP from 1949 to 1968 is now estimated to have been 8.1 per cent in current dollars and 5.2 per cent in constant dollars.* The rate of growth in the GNP between 1949 and 1967 in current dollars and in constant dollars, using the old statistics had been estimated at 7.6 per cent and 4.5 per cent respectively.

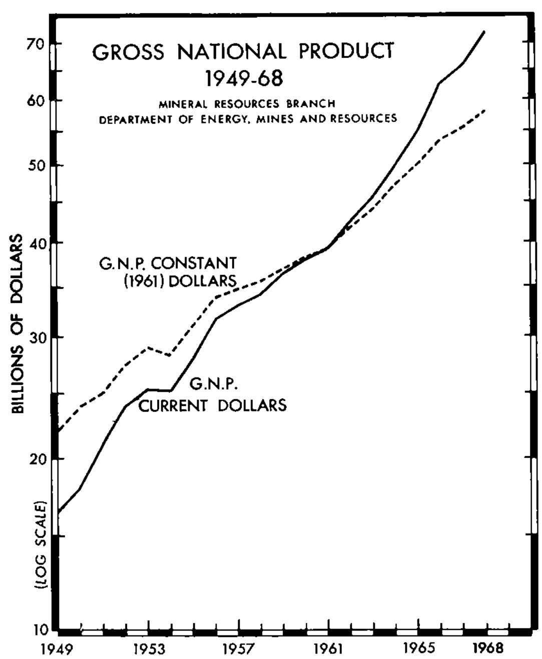


Figure 1

*All statistics used in the text and in diagrams have been taken from publications of the Dominion Bureau of Statistics, unless otherwise noted.

Canada's GNP reached a new high of $71.4 billion in 1968, compared with $65.6 billion in 1967, an increase of 8.9 per cent. Previous estimates had placed the GNP at $62.1 billion in 1967, and $67.3 billion in 1968. Prices rose 4.2 per cent in 1968, reducing the growth rate of GNP in real terms to 4.7 per cent. Prices rose 3.5 per cent in 1967 giving a real gain of 3.3 per cent. Figure 1 shows the behaviour of Canada's GNP in current dollars, and in real, or constant, dollars from 1949 to 1968.

The labour force in Canada grew from an annual average of 7.69 million persons in 1967 to 7.91

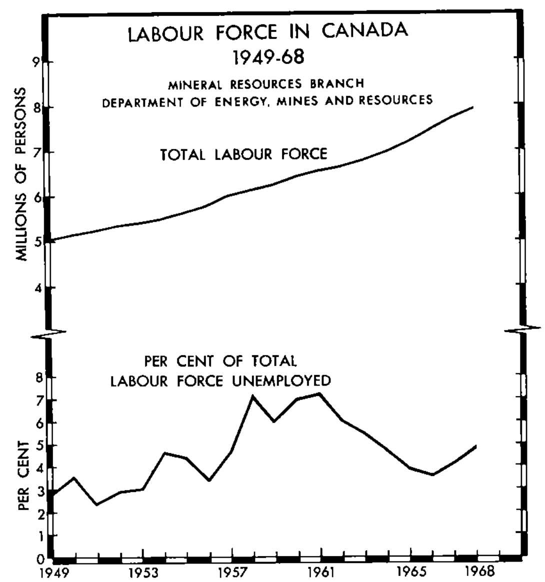
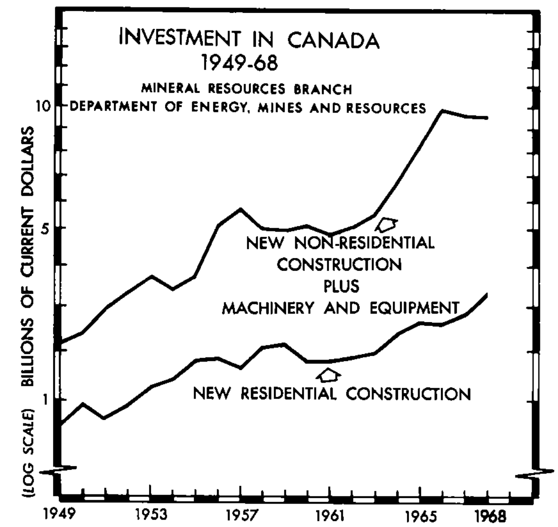


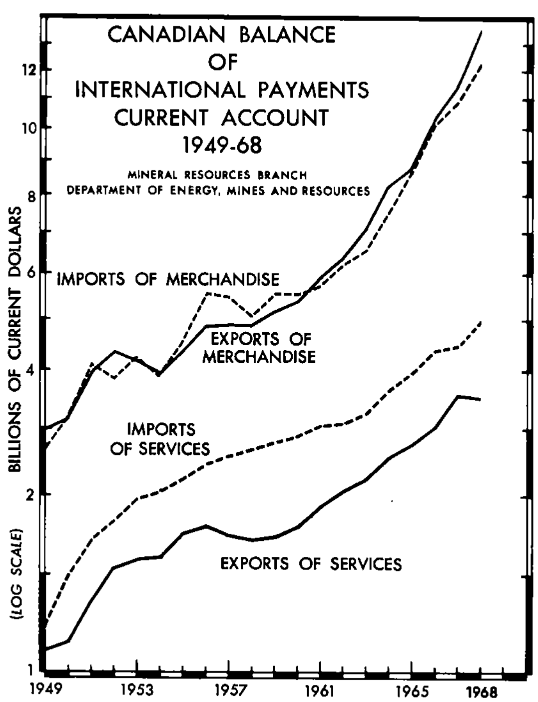
Figure 2

million persons in 1968, an increase of 2.9 per cent, while the number of people employed rose from 7.38 million to 7.53 million, an increase of 2.0 per cent. That is, the labour force rose by 225 thousand persons but the number of people employed increased by only 158 thousand. The overall rate of people unemployed and seeking work in 1968 was 4.8 per cent of the labour force compared with 4.1 per cent in 1967. Figure 2 shows the historical trend in the size of the Canadian labour force and the unemployment rate.



▲ Figure 3

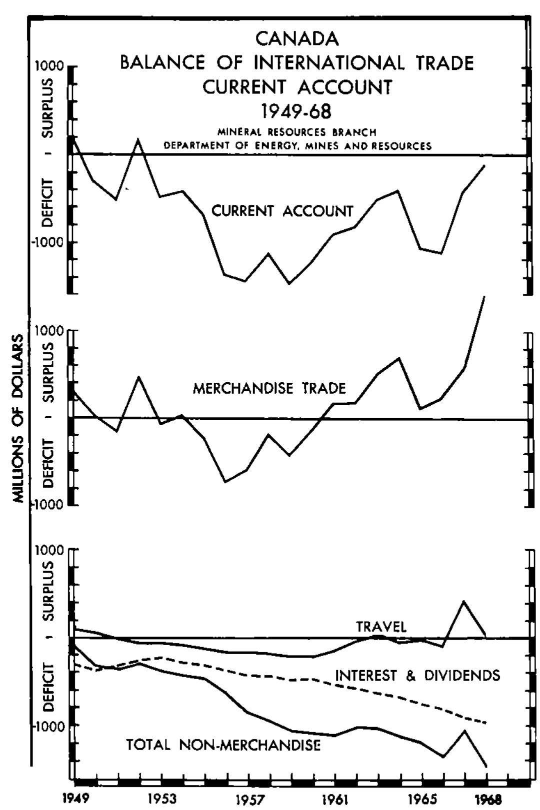
Figure 4 ▼



All five sectors of Gross National Expenditure (GNE), which is numerically equivalent to GNP, increased in 1968 according to the revised version of the National Accounts. These sectors are Personal Expenditures on Consumer Goods and Services, Government Expenditures on Goods and Services and Gross Fixed Capital Formation, Gross Fixed Capital Formation by Business, Value of Physical Change in Inventories, and Net Foreign Trade. In 1968, Personal Expenditures rose to $42.4 billion from $39.0 billion in 1967, an increase of 8.7 per cent compared with an 8.2 per cent rise the previous year. This element of domestic demand does not include large expenditures by foreign tourists.

Business gross fixed capital formation, including residential construction, was $12.8 billion in 1968, or 2.9 per cent above 1967. Within this total, investment in residential construction increased 17.3 per cent and business expenditure on plant and equipment decreased 1.3 per cent, Figure 3. Government expenditures amounted to $12.1 billion in 1968 compared with $10.9 billion in 1967, an increase of 11.0 per cent.

Figure 5



Exports of goods and services from Canada rose to $17.1 billion in 1968, which is 13.6 per cent above the 1967 total. Imports rose by 11.2 per cent to $17.2 billion, giving a deficit on current account of $0.1 billion, compared with a deficit of $0.5 billion in 1967. Current account comprises merchandise and non-merchandise trade. Merchandise exports in 1968 were $13.5 billion, $2.2 billion or 19.4 per cent higher than in 1967. Most of this increase was in trade with the United States; automobiles, other motor vehicles, engines and parts, and aircraft engines and parts comprising a major part of the increase. Increases in wheat sales to China in 1968 partly offset the decrease in sales to India, Japan and several European and Asian countries. Merchandise imports were 12.9 per cent higher in 1968 than in 1967 and totalled $12.2 billion. Imports of automobiles and automotive parts, aircraft and parts, coal, and crude petroleum all increased.

On the non-merchandise, or service account the deficit increased from $1.06 billion in 1967 to $1.49 billion. The largest single item in current payments out of Canada on non-merchandise account is interest and dividends; this increased by $79 million in 1968 from 1967 and amounted to $1,290 million. Interest and dividend receipts increased by only $36 million to $331 million in the same period; thus the net deficit on this item of the current account increased by 4.6 per cent to $959 million in 1968. Canada's Balance of International Payments on Current Account from 1949 to 1968 is shown in Figure 4. The balance of merchandise trade is shown in Figure 5, together with the chief components contributing to the deficit in non-merchandise trade.

The deficit on Current Account must be balanced by capital movements and official transactions. Figure 6 shows the behaviour of Net Capital Movement and the major components of the Capital Account from 1949 to 1968. The large surplus in net capital movement indicates inflow of capital into Canada that was, in part, responsible for the rapid growth of the mineral industry which contributes such a large amount to the Canadian economy. The two major components of this capital flow are: Net Direct Investments, i.e., the difference between investment in Canada by foreigners and investment abroad by Canadians, and Trade in Canadian Securities, i.e., Canadian bonds, debentures and stock delivered to non-residents, and payments to non-residents on the retirement of Canadian securities.

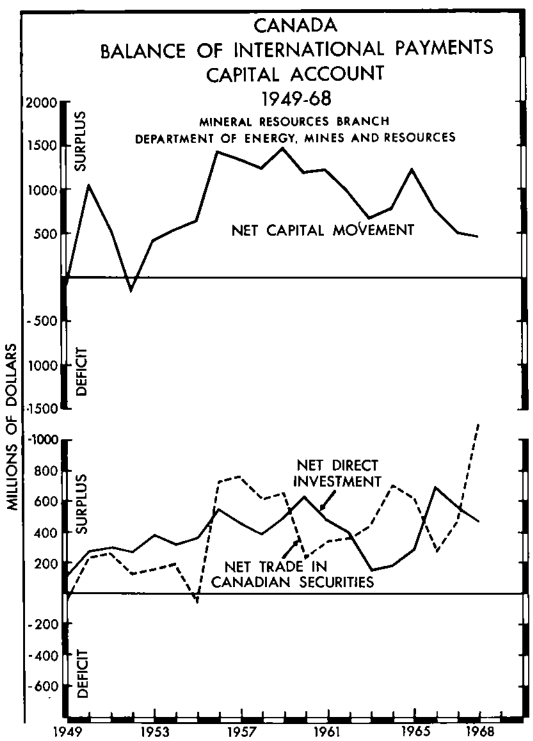


Figure 6

A REVIEW OF THE MINERAL ECONOMY

The value of output of the Canadian mineral industry was a record in 1968, for the tenth consecutive year. Output of most major mineral commodities increased; several new mines started operating and production facilities at others were enlarged.

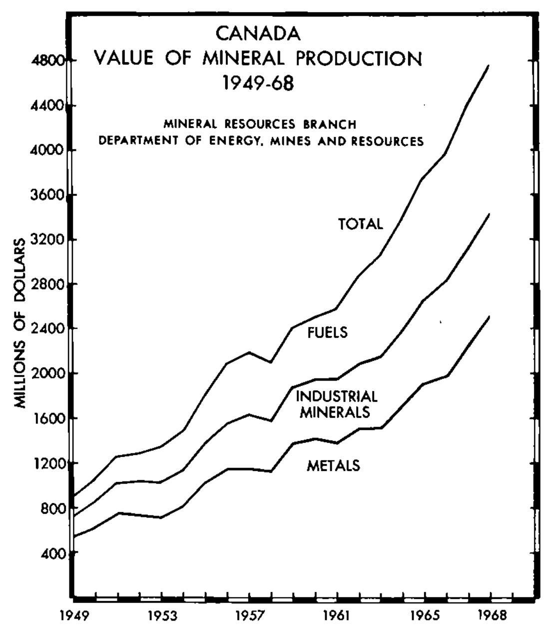


Figure 7

Production in Major Sectors of the Mineral Industry,+ 1967-68

millions of dollars

	1967	1968	Per Cent Change 1967 to 1968
Metals	2,285.3	2,505.8	9.7
Industrial Minerals	852.5	904.2	
Nonmetals	(406.3)	(459.8)	13.3
Structural Materials	(448.2)	(444.4)	-0.9
Fuels	1,258.9	1,353.1	7.5
Total	4,398.7	4,763.2	8.3

+Includes Clay Products, Cement and Lime.

Exploration activity continued at a high level in many parts of the country, extending as far north as the Canadian Arctic Islands. Development continued in several areas, particularly at nickel, copper, uranium, zinc-lead and coal properties, where production within the next two or three years will add substantially to the Canadian total. The value of Canadian mineral production* in 1968 was $4,763 million, 9.7 per cent higher than the revised value of $4,399 million for 1967. Each of the three major sectors of mineral production reached record levels in 1968, their growth in 1967 and 1968 is shown in the table below. Growth since 1949 is shown in Figure 7.

In term of increase in physical volume of output the index of total mining production, including milling, quarries and oil wells, rose from 145.2 in 1967 to 152.7 in 1968, an increase of 5.2 per cent.** Output of metals rose 6.4 per cent, fuels rose 4.0 per cent and total nonmetals rose 1.7 per cent.†

The value of production of all leading minerals increased in 1968. Crude petroleum output rose in value by $73 million, or 8.4 per cent, to $938 million; this was the largest value of any single mineral industry commodity. Copper production continued in second place in terms of value, and at $596 million was 2.2 per cent greater than in 1967. Iron ore production at $556 million was $86 million, or 18 per cent higher than in 1967. Nickel production was valued at $527 million, 13.8 per cent above the 1967 level. Production of zinc was valued at $330 million, 2.5 per cent above the previous year's level, and the

Canada's Ten Leading Minerals, 1965-1968

	Value in Millions of Dollars				Per Cent of Total Mineral Production			
	1965	1966	1967	1968	1965	1966	1967	1968
Petroleum	722	792	865	938	19.3	19.9	19.7	19.7
Copper	381	454	583	596	10.2	11.4	13.3	12.5
Iron Ore	413	432	470	556	11.0	10.9	10.7	11.7
Nickel	430	377	463	527	11.5	9.5	10.5	11.0
Zinc	248	291	322	330	6.6	7.3	7.3	6.9
Natural Gas	187	178	198	233	5.0	4.5	4.5	4.9
Asbestos	146	164	165	190	3.9	4.1	3.7	4.0
Cement	142	156	143	157	3.8	3.9	3.2	3.3
Sand and gravel	134	152	144	128	3.6	3.8	3.3	2.7
Gold	136	125	113	104	3.6	3.1	2.6	2.2
Total	2,939	3,121	3,466	3,759	78.5	78.4	78.8	78.9
All others	806	852	933	1,004	21.5	21.6	21.2	21.1
Total	3,745	3,973	4,399	4,763	100.0	100.0	100.0	100.0

* Mineral production measured on a commodity basis; for a description of the commodity basis of statistical reporting, as distinct from the mining industry basis, please see the preface to the Statistical Tables on page 13.

**Mining industry basis, does not include Clay Products, Cement and Lime.

† More complete statistical information is available in the Statistical Tables at the end of this article.

value of natural gas production, at $233 million, was up 17.7 per cent. Asbestos production, at $190 million, was up 21.2 per cent, which reversed the trend of the previous year. However, the value of production of coal, gold and uranium continued to decline. The value of silver production rose very sharply to $106 million, an increase of 43 per cent. Output of Canada's ten leading minerals was worth $3.76 billion in 1968 and constituted 78.9 per cent of total mineral industry output, as shown in the following table.

Figure 8 shows the distribution of Canadian mineral production, in terms of value of output, by provinces and by commodity in 1968. Ontario remained the leading mineral producer and increased its share of total production to 28.3 per cent. Alberta became the second province to produce more than $1 billion worth of minerals in one year; Ontario was the first in 1967. Alberta's share of total production in 1968 remained almost unchanged at 22.9. The Province of Quebec's share dropped to 15.4 per cent with the absolute value of output also declining, see Table 7 in the Statistical Tables. British Columbia and Saskatchewan each dropped slightly in their share of total production, as did the Northwest Territories, New Brunswick and Nova Scotia. Manitoba's share increased slightly.

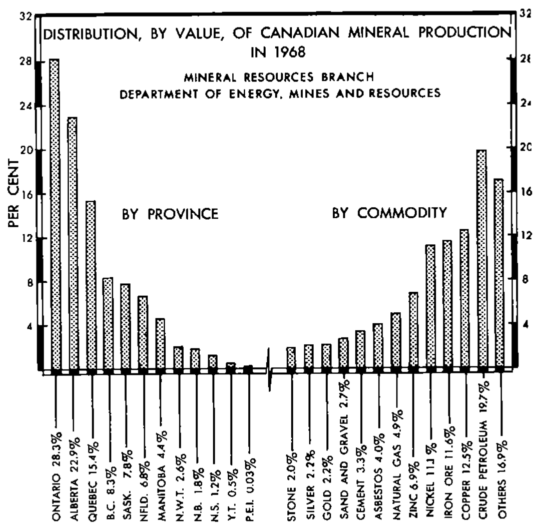


Figure 8

Canada's mineral production and Gross National Product (GNP), both expressed in terms of dollars per head of the population, are shown in Figure 9 (Table 2 of the Statistical Tables. In 1968 the growth of these series was 7.2 per cent for GNP per head, and 6.0 per cent for mineral value per head. The figure also shows, for comparison, the same series for the United States; in that country in terms of value per head, mineral production has fallen behind the Canadian level, while GNP is considerably higher. In absolute terms, in 1968, the value of the United States GNP was about $866 billion (U.S.) and value of mineral production was about $25 billion (U.S.)*

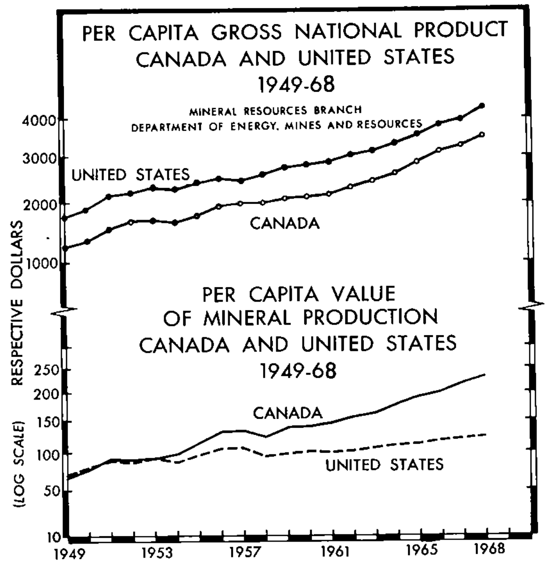


Figure 9

The indexes of production shown in Figure 10 are part of the series, "Real Domestic Product by Industry", according to the 1960 Standard Industrial Classification (SIC) with a 1961 base, but recalculated to 1949 = 100. The Composite Index of Industrial Production has an annual compound rate of growth of 6.0 per cent for the period shown in the figure (1949 to 1968). The rate of growth for Electric Power Utilities is 9.0 per cent a year. For Total mining, including milling, quarries, and oil wells the rate of growth is 8.0 per cent a year. For Total manufacturing the rate of growth is 5.3 per cent a year from 1949-68.

The relation between output and employment in mining and in manufacturing for Canada and for the United States is shown in Figure 11. Each graph represents the ratio:

Index of Industrial Production, by Sector.
Index of Employment, by Sector.

The Canadian and United States ratios should not be correlated directly since their statistical bases are not necessarily the same.

*United States.	Department of Commerce, Bureau of the Census, Office of Business Economics, "Survey of Current Business", Vol. 49, No. 10, p. S-1, October 1969.
United States.	Department of the Interior, Bureau of Mines, "News Release", January 9, 1969.

However, the series have statistical continuity within themselves and the figure illustrates the different rates of growth between sectors. The manufacturing series in Canada and the United States exhibit a similar growth rate. The growth rate in the mining series in both countries is higher than the rate in manufacturing, and the Canadian mining series has a higher rate of growth than the American series.

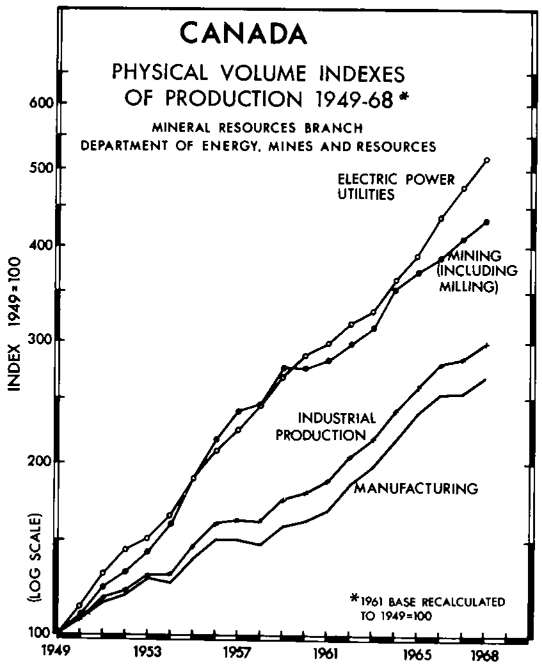


Figure 10

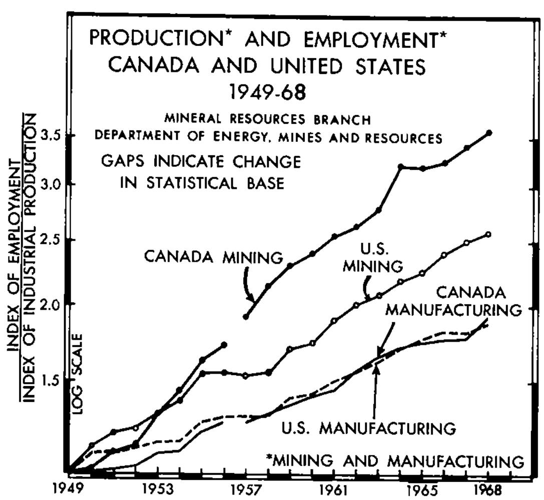


Figure 11

Capital expenditures in the Canadian mining industry reached a peak of $1,051 million in 1967, as is shown by the revised statistics, Table 61 of the Statistical Tables. The estimate of investment for 1968 and the forecast for 1969 are at about the same level. Figure 12 indicates that little change occurred in either the petroleum and natural gas industry, or in all other mining in 1968. However, in 1969, the fall of nearly $100 million of intended investment in all other mining was nearly balanced by an increase of about $70 million in intended investment in petroleum and natural gas extraction.

METAL AND MINERAL PRICES

Mineral and metal markets were mixed during 1968; some commodities, including nickel and aluminum, rose in price, others, including copper, potash and sulphur, fell. Price changes in the major mineral commodities are summarized below; for details on price behaviour the individual commodity reviews in this Yearbook should be consulted.

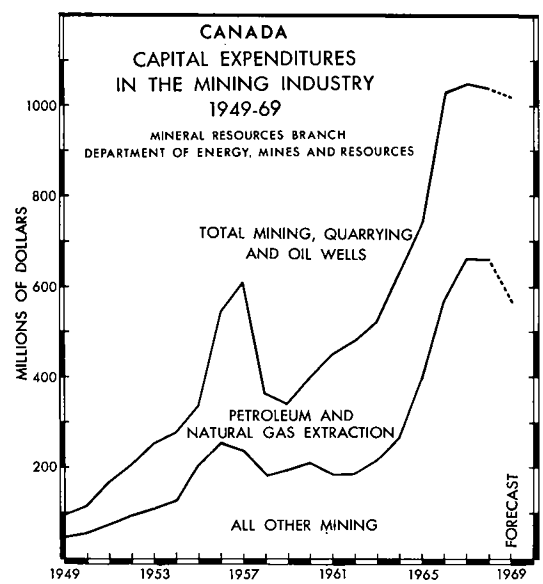


Figure 12

Copper was in short supply early in 1968 because of strikes at mines and smelters in the United States. In Canada, the producer's price of copper remained at 51 cents (Canadian) a pound for the first six months of the year, when it fell to 45 cents as the supply situation eased. United States' producers resumed their price quotations, which had been suspended during the strike period, in April 1968 at 42.0-42.25 cents a pound. It remained at that price, which is equivalent to 45 cents Canadian, throughout the year. Copper prices on the *London Metal Exchange (LME)* were about 63 cents (U.S.) a pound, equivalent, at the beginning of the year, but they rose to a high of 87.6 cents a pound in February under the influence of the shortage caused by the United States strike. The LME price declined to the 48-52 cent range in May and remained at that level until December when it rose to about 55 cents and closed the year at about 53-54 cents. The price of zinc in North America was stable throughout 1968, at 13.5 cents a pound. The LME price was also relatively stable and remained between £107⅜ to £116 a long ton, i.e., between 12 and 13 cents (U.S.) a pound, equivalent. The Canadian price of lead, f.o.b. Toronto and Montreal, which was 14 cents a pound at the beginning of 1968, dropped in May to 13 cents. In October it moved up to 13.5 cents and remained at that level for the rest of the year. The United States domestic price for common lead, f.o.b. New York, was 14 cents a pound from the beginning of 1968 until May when it dropped to 13 cents. A second reduction to 12.5 cents occurred in July. In October the price was increased to 13 cents at which it remained for the rest of the year. On the LME, the settlement and cash seller's price fluctuated between £91.50 and £109.00 a long ton, that is, about 10-11.5 cents, (U.S.) a pound equivalent.

The price of electrolytic nickel remained at 101.5 cents a pound (Canadian) f.o.b. refinery during 1968 until December 27, when it rose to 111.25 cents a pound. The price of iron ore in eastern Canada reflects the Lake Erie base price. Base prices of various grade of iron ore have not changed since mid-1963. Prices received by British Columbia mines on iron ore sales to Japan are negotiated between producers and consumers. Recently negotiated contracts call for somewhat lower prices because of competitive marketing conditions in Japan that have been caused by greater availability of supplies from Australia. Quoted prices paid by Japanese steel producers are given in the iron-ore chapter of this volume.

The price of molybdenum was unchanged at year-end. The price of cobalt in the United States was also unchanged, as was the price of columbium metal, although quotations for long-term Canadian ore contracts were down. Prices paid by the United States for Canadian tungsten were unchanged. Vanadium pentoxide prices declined 20-25 per cent. Aluminum price, in Canada, rose from 26.5 cents a pound, the level it had maintained for a year and a half, to 27.5 cents a pound in June 1968, but the domestic magnesium price remained unchanged at 31 cents a pound.

Contracts were signed for the sale abroad of Canadian uranium, but sale prices were not disclosed. Asbestos prices in Canada were raised about 2 per cent, mid-year, and some producers announced further increases of 5 to 10 per cent effective at year-end. Potash prices continued to weaken during 1968. Sulphur prices also declined toward year-end after rising over a period of several years.

Figure 13 shows the behaviour of price indexes of iron, non ferrous, and nonmetallic mineral products in juxtaposition with retail and wholesale price indexes. Iron products, historically the highest index in the 1935-39 = 100 base, showed the smallest increase in 1968, only 0.8 per cent. The price of nonferrous products rose almost the same amount as the retail price index, about 4.2 per cent, although producers' prices of most nonferrous metals in Canada did not rise appreciably. Nonmetallic mineral product prices rose about 3.4 per cent.

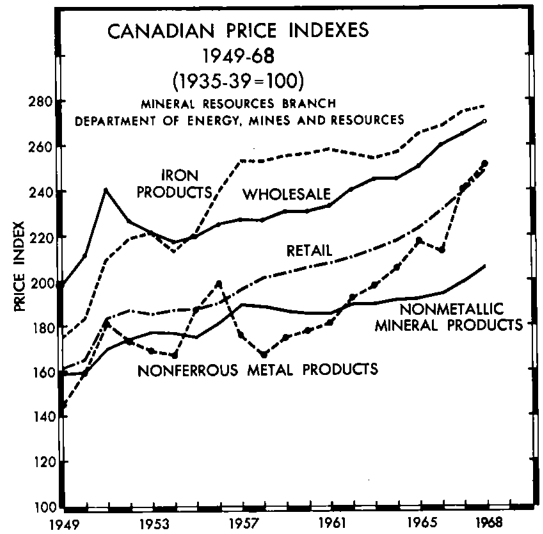


Figure 13

MINERAL TRADE

The value of crude minerals and fabricated mineral product exports rose to $4.10 billion in 1968, which was $634 million or 18.3 per cent higher than in 1967. All main commodity groups showed increases with ferrous minerals showing the largest percentage increase, Table 12 in the Statistical Tables. The 34.6 per cent increase in ferrous fabricated material class exports was mainly because of a 22.9 per cent increase in exports of plate, sheet and strip steel, chiefly to the United States. Total crude mineral exports increased 20.6 per cent with increases in exports of petroleum, and iron ores and concentrates. The value of mineral imports increased in total, but some commodity groups such as nonmetals showed a decline in value.

Crude and fabricated mineral exports comprised 31 per cent of total Canadian merchandise exports in 1968, the same proportions as in 1967, Figure 14. Mineral imports, however, fell from 17.4 per cent of total merchandise imports in 1967 to 16.5 per cent in 1968, although in absolute terms they rose from $1,935 million to $2,046 million.

Canadian mineral exports to the United States were $450 million more than in 1967. This represented over 70 per cent of the total increase in mineral exports, and the United States' share of total mineral exports increased to 60.2 per cent from 58.3 per cent in 1967, Figure 16. The value of exports of most major mineral commodity exports to the United States increased; but the value of molybdenum and uranium exports decreased.

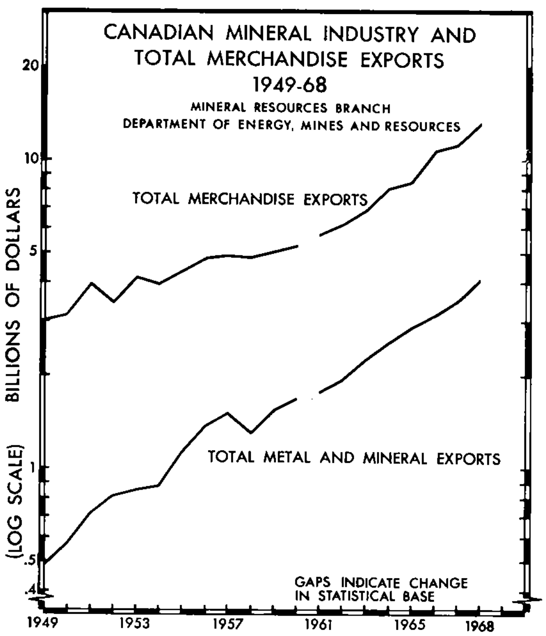


Figure 14

Mineral exports to Britain in 1968 were valued at $44 million, 8.7 per cent higher than in 1967 and comprised 13.4 per cent total Canadian mineral exports, a slightly lower proportion than the previous year. The major increases were in iron ore, copper, and nickel. Commodities lower in total export value in 1968 were aluminum and zinc.

The share of Canadian mineral exports to EFTA* nations other than Britain fell to 1.3 per cent from 2.9 per cent in 1967. The value of mineral exports to EEC** countries rose from $260 million in 1967 to $335 million in 1968; this represented an increase from 7.5 per cent to 8.2 per cent of total Canadian mineral exports. Exports to Japan increased from $272 million to $295 million; that is, to 7.8 per cent from 7.2 per cent of total Canadian mineral export trade.

Copper exports in 1968 were valued at $612 million up $117 million from 1967, making copper the most valuable mineral commodity export. Crude petroleum exports increased 12 per cent from $398 million in 1967 to $446 million in 1968, reflecting the

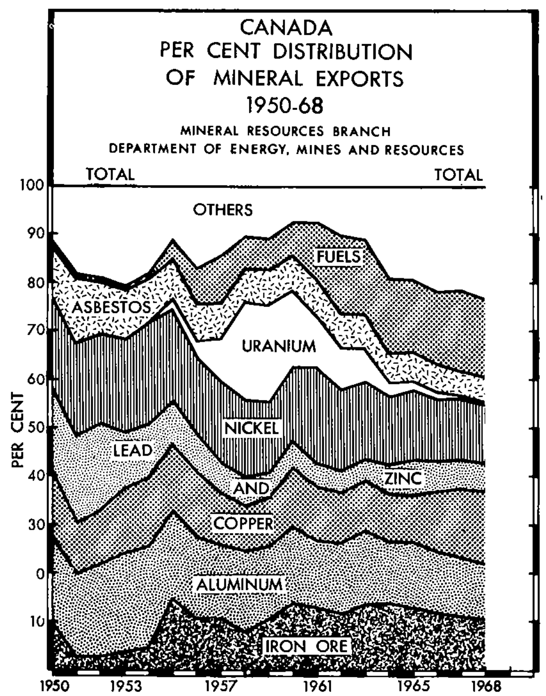


Figure 15

increasing demand by United States refineries for Canadian feedstock. Natural gas exports rose 26 per cent from $124 million to $157 million in 1968. The growth rate of natural gas exports to the United States is expected to increase in future years as the gas supply situation becomes more critical especially in the midwestern and west coast areas. All other main mineral commodity exports increased in value in 1968; nickel exports rose 16.9 per cent, iron ore exports rose 15.7 per cent, aluminum exports rose 11 per cent, and zinc exports increased 6.1 per cent. The value of asbestos and uranium exports increased 12.1 per cent and 9.2 per cent respectively.

* European Free Trade Association countries are: Britain, Austria, Denmark, Norway, Portugal, Sweden and Switzerland.

**European Economic Community (Common Market) countries are: Belgium, France, Italy, Luxembourg, Netherlands and West Germany.

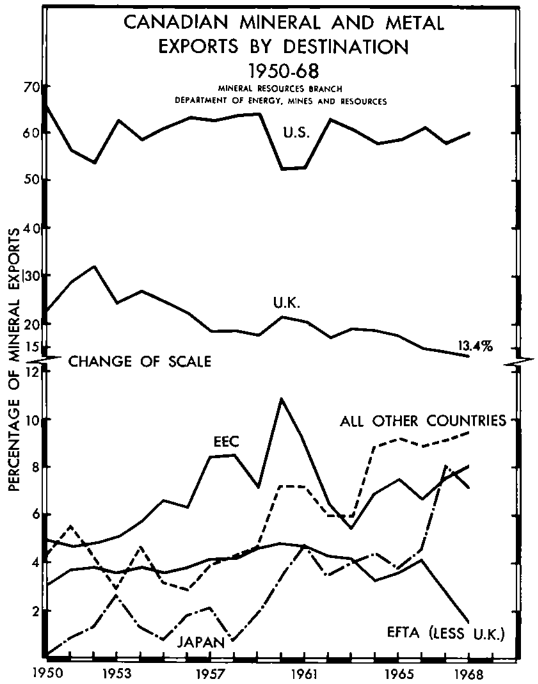


Figure 16

REVIEW BY PROVINCES

BRITISH COLUMBIA

Value of mineral production in 1968 amounted to \$397 million, \$17 million more than in 1967. Copper was the principal mineral, accounting for 20 per cent of the total value of production. Lead and zinc together accounted for 19 per cent, and petroleum for 13 per cent.

Development continued at the Brenda copper-molybdenum mine near Penticton, and at the Granduc mine, near Stewart, in northern British Columbia. Exploration continued at several large copper and copper-molybdenum deposits in the Highland Valley district. Cominco Ltd. operated two lead-zinc mines and metallurgical plants in the southeastern part of the province producing refined zinc, lead, byproduct metals, industrial chemicals, and fertilizers. Molybdenum production declined because of a three-and-one-half-month strike at the province's largest molybdenum mine, operated by Endako Mines Ltd. Canada's newest molybdenum producer, British Columbia Molybdenum Limited, completed a full year of operations in 1968 at Alice Arm. Two of the six iron-concentrate producers in the province suspended production.

Kaiser Coal Ltd. concluded a contract in 1968 for the export to Japan of coking coal to be produced from a large surface mine in the Natal-Fernie area of southeastern British Columbia. The contract is for 45 million long tons to be shipped over a 15-year period beginning in 1970. Negotiations for export contracts were in progress during the year by other companies with coal reserves in the province.

YUKON TERRITORY AND NORTHWEST TERRITORIES

Mineral production in the Yukon Territory increased by \$9 million to \$24 million in 1968. Metals, which in the past accounted for nearly all the output, were in 1968 only 56 per cent of the total. Asbestos became the most important single mineral with the opening late in 1967 of the Clinton Creek mine, 65 miles west of Dawson; production totalled 64,000 tons valued at \$10 million. The value of silver, lead and zinc production declined sharply because of the curtailment of output in the Mayo district. Development of the Anvil zinc-lead mine at Ross River continued during the year.

Production of minerals in the Northwest Territories continued to increase. Eighty per cent of the total was accounted for by lead, zinc and cadmium from the Pine Point mine on the south shore of Great Slave Lake. Cominco Ltd., which operates this mine, increased the capacity of the existing 5,000-ton mill by 60 per cent to treat the ore from the nearby Pyramid mine. Gold from Yellowknife-district mines accounted for 11 per cent of mineral output.

Panarctic Oils Ltd., a consortium of 20 companies in partnership with the federal government, completed preliminary surveys of selected areas in the Arctic Islands. During the latter part of 1968, as a result of the Prudhoe Bay oil discovery in adjacent Alaska, millions of acres of land were taken under exploration permit along the Canadian Arctic coastline. A number of companies carried out deep diamond drilling during 1968 on Richards Island in the Mackenzie River delta.

ALBERTA

In 1968 Alberta became the second province to produce one billion dollars worth of minerals in a year. Total output was valued at \$1.09 billion. Mineral fuels accounted for 89 per cent of the total, byproduct sulphur for 7 per cent, and structural materials for 3 per cent. Petroleum production increased by \$62 million and natural gas by \$24 million.

Early in 1968 the Alberta government revised its policy on production of oil from the Athabasca tar sands. The most important change was that allowable production from this resource was raised from 45,000 to 150,000 barrels daily. As a result, Syncrude Canada Ltd. reapplied for approval of its plan to produce 80,000 barrels of petroleum a day from the sands. Although the Conservation Board turned down its application mainly because of inadequate markets, Syncrude, late in the year, applied directly to the Alberta government for permission to proceed with its program.

Alberta in 1968 became the leading coal producing province in Canada. This advance is seen as the first stage in the development of a significant coal industry once again in Alberta based on large exports of coking coal to Japan beginning in 1970. Shipments to the western United States are scheduled to begin at a later date.

SASKATCHEWAN

Mineral production in all sectors was at about the same level in 1968 as in 1967. The mineral fuels, principally petroleum, accounted for 60 per cent of the total value of production, potash and other nonmetallics for 23 per cent, and copper, zinc and uranium for 11 per cent.

Potash since 1963 has been the fastest growing of Saskatchewan's minerals and in 1968 increased in production value by 10 per cent. Four potash mines were in production during the year, three others were brought into production, three others were under development. Competitive marketing conditions forced some potash producers to reduce production below capacity levels.

Copper production came from several mines at or near Flin Flon, those of Hudson Bay Mining and Smelting Co., Limited being the principal producers. Hudson Bay produced substantial amounts of zinc and silver as well as copper, and treated its own and custom ores at the Flin Flon copper-zinc smelter. Eldorado Nuclear Limited, one of four Canadian uranium producers, operated its mill at Beaverlodge in northern Saskatchewan at 85 per cent of capacity and continued development of the Hab mine near Beaverlodge. Late in 1968, Gulf Minerals Company announced results of drillings in the Wollaston Lake area, causing a land acquisition rush which resulted in the issuing of exploration permits covering several million acres.

MANITOBA

Mineral production was valued at $208 million, $23 million more than in 1967. The principal increase was in the output of nickel, which accounted for nearly 60 per cent of the province's total mineral production. Output of copper was much the same as in 1967 and accounted for 14 per cent of the total. Petroleum and the structural materials made substantial gains.

The International Nickel Company of Canada, Limited (Inco) operated the Thompson mine, smelter and refinery, and Sherritt Gordon Mines, Limited operated the Lynn Lake nickel mine in northern Manitoba. Inco carried out mine development in the Thompson area, preparing three mines for production. Hudson Bay Mining and Smelting Co., Limited opened a copper-zinc mine in the Snow Lake district in 1968 and carried out development at two deposits in the same district. Development continued at the Fox Lake property of Sherritt Gordon Mines, Limited. The province's only gold mine, the San Antonio mine at Bissett, suspended operations in 1968.

ONTARIO

Mineral production in Ontario was valued at $1,350 million, $155 million higher than the previous year. Nickel continued to be the most important mineral, valued at $404 million. Second most important was copper, the value of production of which was $278 million in 1968; thus these two metallic minerals accounted for 50 per cent of total mineral production in the province. Production of nickel, and of copper, was maintained at a high level by Inco and Falconbridge Nickel Mines, Limited in the Sudbury district. Inco opened a new mill, carried out development of four new mines, and announced that a new nickel refinery would be built at Sudbury. The company carried out development of a nickel deposit near Port Arthur, where production is scheduled to begin in 1971. Falconbridge opened two new mines and began development of another deposit in the Sudbury district.

Copper, zinc, lead and silver production were all substantially higher. The increases were mainly due to increased production at Ecstall Mining Limited's open pit and 9,000-ton concentrator near Timmins, where the first year's operation at full capacity was completed. Production at this mine exceeded that of 1967, which was 3 million tons of ore, 225,000 tons of zinc, 50,000 tons of copper, 5,000 tons of lead, and 7.8 million ounces of silver. Iron ore output in Ontario increased by 28 per cent following the opening of two large new mines, the Griffith and the Sherman.

Uranium production at Elliot Lake was at the same level as in 1967; one new mine was opened and several others were in various stages of reactivation. Mine development continued at the property of Agnew Lake Mines Limited, 30 miles west of Sudbury, where production is scheduled to begin from a 3,000-ton mill in 1972. Development of uranium deposits was also carried out at Bancroft. Eldorado Nuclear Limited began construction of facilities at Port Hope for the production of uranium hexafluoride; production is scheduled to begin in 1970.

Gold production continued to decline. The Teck-Hughes mine at Kirkland Lake and the Hollinger and Preston mines at Timmins closed during the year. The Hollinger began production in 1910 and produced more gold than any other lode gold mine in Canada.

QUEBEC

Mineral output in Quebec, valued at $731 million in 1968 was at almost the same level as in 1967. Production of metals, which accounted for 58 per cent of the total, continued to decline. Output of copper, which is the most important of the metallic minerals, was 156,100 tons, compared with 166,400 tons in

1967 and 172,000 tons in 1966. This decline reflects a falling off in production at several of the province's older mines. Mill expansion from 7,500 to 11,000 tons daily was completed at Murdochville, Gaspé Peninsula, and mining from a new open pit started there early in 1968. Mine development continued at copper properties in the Gaspé Provincial Park, where production at one property is scheduled to start in 1969 from a 2,500-ton mill. Quebec remained in 1968 the province with the second largest value of copper production. Copper concentrates were smelted, for the most part, at Noranda and Gaspé. Zinc output totalled 212,300 tons in 1968, down 33,000 tons from 1967. Zinc concentrates were treated at the Valleyfield reduction plant near Montreal and at foreign plants.

Iron ore production increased by 1.1 million tons to 15.6 million tons. Iron Ore Company of Canada began construction of another ore loading dock at Sept-Iles that will accommodate ships up to 150,000-tons capacity. A new molybdenum mill, to replace the one destroyed by fire in 1967, was built near Val d'Or and started operations late in 1968. Diamond drilling was continued at the nickel deposit of New Quebec Raglan Mines Limited, Ungava, controlled by Falconbridge Nickel Mines, Limited; underground development was deferred pending completion of a feasibility study. Exploration for uranium was carried out in the areas of Mont Laurier, Johan Beetz, Ste. Simeon, and Mistassini.

Asbestos was the leading mineral in Quebec, accounting for 21 per cent of the total value of production. Production totalled 1,369,000 tons, having a value of 11 per cent more than in 1967. Producers in the Eastern Townships continued in 1968 to expand their mining and milling capacity. Milling tests and feasibility studies were carried out on a deposit at Chibougamau estimated to contain 90 million tons of asbestos rock. The Asbestos Hill project in the northern Ungava area remained on a caretaker basis throughout 1968.

NEW BRUNSWICK

New Brunswick's mineral output was slightly less in 1968 than in 1967 mainly because of a drop in the production of structural materials. Metals production, which accounted for nearly 80 per cent of the total, was unchanged at $68 million. Zinc output declined while copper, lead and silver increased. The province's largest mineral-producing operation is that of Brunswick Mining and Smelting Corporation Limited, a subsidiary of Noranda Mines Limited, which produces zinc, lead, copper and silver from two mines at Bathurst and operates a zinc-lead smelter at Belledune. Other Bathurst-district mines are the Heath Steele and the Nigadoo. The Wedge copper mine was closed in 1968 when its ore reserves were exhausted.

Under an agreement between the federal and provincial governments, New Brunswick in 1968 assumed management of the coal mines at Minto, which for some time have required federal subsidies in order to operate. A federal grant of $19.6 million will be paid over a four-year period beginning in 1968 under the new agreement.

NOVA SCOTIA AND PRINCE EDWARD ISLAND

Value of mineral production in Nova Scotia declined further in 1968 to $58 million, mainly because of a large drop in the value of coal following discontinuance of federal coal subvention payments. Coal, which accounted for half the province's total mineral output value, declined from $51.7 million in 1967 to $30.4 million in 1968. Nonmetallics, principally gypsum and salt, increased in value of output by 15 per cent.

Ten coal mines were in operation in Nova Scotia during 1968. Since 1966 the federal and provincial governments have co-operated to develop programs designed to end the subsidization of the Cape Breton coal mines. Cape Breton Development Corporation, formed in 1967 by the federal government in co-operation with the Government of Nova Scotia, in 1968 continued its efforts to rationalize the coal mining industry, and to promote and finance the development of other industries on Cape Breton Island.

Prince Edward Island's mineral production consists of structural materials which were valued at $1.4 million in 1968.

NEWFOUNDLAND AND LABRADOR

Mineral production increased by 21 per cent in 1968, totalling $324 million. The increase was due almost entirely to a rise of 4.1 million tons and $55 million in shipments of iron ore, which accounted for 81 per cent of the province's mineral output.

Iron Ore Company of Canada completed an expansion program begun in 1967 that increased the annual pellet-producing capacity of its Carol plant in Labrador from 5.5 million to 10 million long tons. The expansion makes this pellet plant one of the three largest in the world, each capable of producing 10 million tons or more of pellets a year.

Copper is the next most important mineral and accounted for 7 per cent of total output with production coming from five mines on the Island of Newfoundland. The mines shipped copper concentrates to Canadian and foreign smelters with zinc and lead being the principal products at one of the five, the Buchans mine.

Statistical Tables

Statistics reported are derived from publications of the Dominion Bureau of Statistics (DBS). However, different concepts are involved in different sections and totals may not always be strictly comparable. The customary, commodity basis of valuation is used in the production section. Value of mineral production of each commodity is reported, the point of valuation being f.o.b. mine, smelter, refinery, or producing-field pipeline. Statistics on consumption also refer to minerals on a commodity basis.

However, statistics in all other sections except Trade and Transportation are reported on an "industry" basis (revised Standard Industrial Classification). Under this concept the term "mining" industry refers to mining, quarrying and oil wells; not included are sectors of the mineral processing industry classified within manufacturing. Output of such mineral processing sectors includes nonferrous smelting and refining products, iron and steel mill, pipe, tube, and foundry products and other mineral products including cement, ready-mix concrete and some glass manufactures, coal products and petroleum products. Where production data are reported on an industry basis, which excludes some material reported by DBS as manufactures, such as cement and lime, these exclusions are reported as footnotes to tables.

Trade data include, under the title of fabricated mineral products, items that have been subject to some processing but are not of direct use in themselves. Included among mineral-based fabricated material are some, such as steel and aluminum, that are not included in the gross production value statistics.

STATISTICAL TABLES

TABLE 1

Canada, Mineral Production, 1967 and 1968

	Unit of Measure	1967		1968P	
		Quantity	$ 000	Quantity	$ 000
Metals					
Antimony	000 lbs	1,268	672	1,124	596
Bismuth	"	668	1,919	640	2,435
Cadmium	"	4,836	13,542	5,438	15,288
Calcium	"	544	535	446	422
Cobalt	"	3,604	7,352	3,979	8,544
Columbium (Cb_2O_5)	"	2,160	2,404	2,118	2,393
Copper	000 st	613	582,585	620	596,450
Gold	000 troy oz	2,986	112,732	2,748	103,640
Indium	000 oz	..	..	..	..
Iron Ore	000 lt	37,784	470,122	44,083	555,913
Iron remelt	000 st	..	18,585	..	22,523
Lead	"	318	89,030	347	93,797
Magnesium	000 lb	17,775	5,653	19,757	6,153
Mercury	"	–	–	..	..
Molybdenum (Mo content)	"	21,377	37,900	22,301	40,324
Nickel	000 st	249	463,140	264	527,005
Platinum group	000 troy oz	401	34,669	464	44,025
Selenium	000 lb	725	3,514	709	3,280
Silver	000 troy oz	36,315	62,898	45,621	105,750
Tellurium	000 lb	73	476	65	420
Thorium	"	117	214	139	269
Tin	"	438	622	335	553
Titanium ore	000 st	–	–	–	–
Tungsten (WO_3)	000 lb	..	..	..	..
Uranium (U_3O_8)	"	7,476	53,022	7,400	45,482
Yttrium	"	173	1,594	111	935
Zinc	000 st	1,111	322,099	1,169	329,610
Total metals			2,285,279		2,505,807
Nonmetals					
Arsenious oxide	000 lb	755	48	693	52
Asbestos	000 st	1,452	165,119	1,596	190,068
Barite	"	172	1,573	138	1,581
Diatomite	st	..	..	..	..
Feldspar	000 st	10	242	11	259
Fluorspar	"	..	2,100	..	2,475
Gemstones	000 lb	24	28	7	10
Grindstone	st	10	3	–	–
Gypsum	000 st	5,175	11,348	6,145	13,159
Helium	Mcf	..	..	..	..
Iron oxide	000 st	0.7	37	0.6	33
Lithia	000 lb	437	266	–	–
Magnetic dolomite and brucite	000 st	..	3,516	..	2,719
Mica	000 lb	..	..	..	..

TABLE 1 (Cont'd.)

	Unit of Measure	1967		1968P	
		Quantity	$ 000	Quantity	$ 000
Nonmetals (cont'd.)					
Nepheline syenite	000 st	402	4,753	425	4,929
Nitrogen	Mcf	..	..	..	..
Peat Moss	000 st	281	8,006	288	8,618
Potash	"	2,383	67,396	2,891	73,950
Pyrite, pyrrhotite	"	378	1,703	320	2,215
Quartz	"	2,611	5,530	2,621	6,459
Salt	"	5,361	27,808	4,888	31,908
Soapstone, talc, pyrophyllite	"	61	901	77	1,194
Sodium sulphate	"	428	6,359	469	7,403
Sulphur in smelter gas	"	592	7,182	566	6,952
Sulphur, elemental	"	2,499	68,614	2,586	81,277
Titanium dioxide, etc.	"	..	23,737	..	24,574
Total nonmetallics			406,269		459,835
Fuels					
Coal	000 st	11,123	82,760	10,955	61,098
Natural gas	000 Mcf	1,471,725	198,431	1,692,788	232,556
Natural gas by-products	000 bbl	..	112,780	..	121,723
Petroleum, crude	"	351,292	864,954	379,387	937,794
Total Fuels			1,258,925		1,353,171
Structural Materials					
Clay products	$ million	..	44,357	..	46,264
Cement	000 st	7,995	143,150	8,279	156,541
Lime	"	1,423	16,567	1,366	17,087
Sand and Gravel	"	209,666	143,707	198,529	128,101
Stone	"	80,636	100,416	74,684	96,414
Total Structural Materials			448,197		444,407
Total all minerals			4,398,670		4,763,220

.. Not available or not applicable; – Nil; P Preliminary.

TABLE 2

Canada, Value of Mineral Production and Per Capita Values, Selected Years, 1930-68

	Metallics $ million	Industrial Minerals $ million	Fuels $ million	Total $ million	Per Capita Value $
1930	143	69	68	280	27.42
1935	222	35	55	312	28.77
1940	383	68	79	530	46.57
1945	317	88	94	499	41.34
1950	617	227	201	1,045	76.21
1955	1,008	373	414	1,795	114.35
1960	1,407	520	566	2,493	139.51
1964	1,702	690	999	3,391	175.79
1965	1,908	761	1,076	3,745	190.64
1966	1,985	844[r]	1,151	3,980	198.80
1967	2,285	854	1,259	4,398	215.54
1968[p]	2,506	904	1,353	4,763	229.61

[p]Preliminary; [r]Revised.

TABLE 3

Canada, Indexes of Physical Volume of Total Industrial Production and Mining Production, 1954-68
Unadjusted (1961 = 100)

	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968
Total industrial production	70.0	77.7	85.8	87.2	86.7	94.2	96.2	100.0	109.5	116.5	128.1	139.1	148.9	151.7	159.8
Total mining (including milling) quarries and oil wells	56.1	66.4	77.1	84.6	86.0	97.3	97.4	100.0	104.8	110.6	124.9	131.6	136.5	145.2	152.7
Metals															
All metals	59.0	66.8	72.7	85.5	95.5	110.0	107.3	100.0	101.1	103.9	120.6	124.5	125.0	133.8	142.6
Placer gold and gold quartz mines	99.6	102.7	98.4	100.0	104.1	102.2	104.4	100.0	92.6	88.8	85.3	79.2	71.8	65.4	58.8
Iron mines	36.5	72.7	93.0	97.4	70.7	105.2	103.6	100.0	142.4	173.0	229.5	242.6	261.1	276.1	311.4
Miscellaneous metal mines n.e.s.	..	..	..	..	..	..	..	100.0	95.6	94.8	108.5	112.6	111.5	122.0	129.0
Fuels															
All fuels	49.7	63.0	80.0	83.1	76.5	84.1	87.1	100.0	111.3	119.1	128.3	135.2	145.6	158.0	164.3
Coal	150.7	148.5	149.5	131.1	113.8	103.8	107.0	100.0	97.2	103.7	108.9	108.6	105.9	106.2	96.6
Crude petroleum and natural gas	..	..	..	..	..	..	..	100.0	113.7	121.7	131.7	139.8	152.5	166.9	176.1
Nonmetals															
All nonmetals	73.4	84.0	88.6	84.8	80.3	92.0	91.5	100.0	109.3	121.9	138.7	161.8	179.2	192.8	196.1
Asbestos	75.5	86.3	86.4	83.8	79.8	86.4	90.3	100.0	103.4	109.2	118.9	123.4	134.7	130.6	124.9

. . Not available.

TABLE 4

Canada, Percentage Contribution of Leading Minerals to Total Value of Mineral Production
1959-68

	1959	1960	1961	1962	1963	1964	1965	1966[r]	1967	1968[p]
Petroleum, crude	17.5	17.0	18.9	19.4	20.2	19.9	19.3	19.9	19.7	19.7
Copper	9.7	10.6	9.9	9.9	9.3	9.6	10.2	11.4	13.2	12.5
Iron Ore	8.0	7.0	7.3	9.2	10.3	11.9	11.0	10.8	10.7	11.6
Nickel	10.7	11.9	13.6	13.5	11.8	11.2	11.5	9.5	10.5	11.1
Zinc	4.0	4.4	4.1	3.9	4.0	5.7	6.6	7.3	7.3	6.9
Natural gas	1.6	2.1	2.6	3.8	4.9	5.1	5.0	4.5	4.5	4.9
Asbestos	4.5	4.9	5.0	4.6	4.5	4.3	3.9	4.1	3.7	4.0
Cement	3.9	3.7	4.0	4.0	3.9	3.9	3.8	3.9	3.3	3.3
Sand and gravel	4.3	4.6	4.1	4.2	4.1	3.7	3.6	3.8	3.3	2.7
Gold	6.2	6.3	6.1	5.5	5.0	4.3	3.6	3.1	2.5	2.2
Silver	1.2	1.2	1.1	1.2	1.4	1.2	1.2	1.2	1.4	2.2
Stone	2.5	2.4	2.6	2.4	2.6	2.6	2.5	2.8	2.3	2.0
Lead	1.6	1.8	1.8	1.5	1.5	1.6	2.4	2.3	2.0	1.9
Sulphur, elemental	0.1	0.2	0.3	0.3	0.4	0.5	0.7	1.0	1.6	1.7
Potash (K_2O)	–	–	–	0.1	0.7	0.9	1.5	1.6	1.5	1.6
Coal	3.1	3.0	2.7	2.4	2.4	2.1	2.0	2.0	1.9	1.3
Uranium (U_3O_8)	13.7	10.8	7.6	5.5	4.5	2.5	1.7	1.4	1.2	1.0
Clay products	1.8	1.5	1.4	1.3	1.3	1.2	1.1	1.1	1.0	1.0
Platinum metals	0.7	1.2	0.9	1.0	0.7	0.7	1.0	0.8	0.8	0.9
Molybdenum	0.04	0.04	0.04	0.04	0.04	0.06	0.4	0.9	0.9	0.8
Salt	0.7	0.8	0.8	0.8	0.7	0.7	0.6	0.6	0.7	0.7
Titanium dioxide	0.4	0.5	0.6	0.4	0.5	0.6	0.6	0.5	0.5	0.5
Lime	0.9	0.8	0.7	0.6	0.6	0.6	0.5	0.5	0.4	0.4
Cadmium	0.1	0.1	0.08	0.2	0.2	0.3	0.1	0.2	0.3	0.3
Gypsum	0.3	0.4	0.3	0.3	0.4	0.3	0.3	0.3	0.3	0.3
Other minerals	2.5	2.8	3.5	4.0	4.1	4.6	4.9	4.5	4.5	4.5
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

– Nil; [p]Preliminary; [r]Revised.

TABLE 5

Canada – Value of Mineral Production by Main Geological Regions, 1968p

	Metals		Industrial Minerals		Fuels		Total, all Minerals	
	$ millions	% of total	$ millions	% of total	$ millions	% of total	$ millions	% of total
Canadian Shield	1,992.1	79.5	65.1	7.2	–	–	2,057.2	43.2
Appalachian Region	160.9	6.4	217.6	24.1	37.9	2.8	416.4	8.8
St. Lawrence Lowlands	2.4	0.1	305.0	33.7	8.0	0.6	315.4	6.6
Interior Plains	95.8	3.8	220.0	24.3	1,252.9	92.6	1,568.7	32.9
Cordilleran Region	254.6	10.2	96.5	10.7	54.4	4.0	405.5	8.5
Total, Canada	2,505.8	100.0	904.2	100.0	1,353.2	100.0	4,763.2	100.0

pPreliminary: – Nil.

TABLE 6

Canada, Value of Mineral Production by Provinces and Mineral Classes, 1968p

	Metals		Industrial Minerals		Fuels		Total	
	$000	% of Total	$000	% of Total	$000	% of Total	$000	% of Total
Ontario	1,115,744	44.6	226,082	25.0	7,961	0.6	1,349,787	28.3
Alberta	4	–	114,750	12.7	976,073	72.1	1,090,827	22.9
Quebec	430,828	17.2	300,498	33.2	21	–	731,347	15.4
British Columbia	238,495	9.5	68,951	7.6	89,257	6.6	396,703	8.3
Saskatchewan	45,382	1.8	99,494	11.0	225,565	16.7	370,441	7.8
Newfoundland	303,089	12.1	20,575	2.3	–	–	323,664	6.8
Manitoba	168,575	6.7	24,139	2.7	15,562	1.2	208,276	4.4
Northwest Territories	121,317	4.9	–	–	882	0.06	122,199	2.6
New Brunswick	68,004	2.7	11,623	1.3	7,450	0.6	87,077	1.8
Nova Scotia	1,113	0.04	26,458	2.9	30,400	2.2	57,971	1.2
Yukon	13,256	0.5	10,240	1.1	–	–	23,496	0.5
Prince Edward island	–	–	1,432	0.2	–	–	1,432	0.03
Total	2,505,807	100.0	904,242	100.0	1,353,171	100.0	4,763,220	100.0

– Nil; p Preliminary.

TABLE 7

Canada, Value of Mineral Production by Provinces, 1959-68
($ millions)

	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968p
Ontario	971	983	944	913	874	904	993	958	1,195	1,350
Alberta	376	396	473	567	669	736	794	847	973	1,091
Quebec	441	446	455	519	541	685	716	770r	734	731
British Columbia	159	186	188	235	261	269	280	331	380	397
Saskatchewan	210	212	216	240	272	292	328	349	362	370
Newfoundland	72	87	92	102	138	182	208	244	266	324
Manitoba	55	59	101	159	170	174	183	179	185	208
Northwest Territories	26	27	18	18	16	18	77	111	118	122
New Brunswick	18	17	19	22	28	49	82	90	90	87
Nova Scotia	63	66	62	62	66	66	71	86	77	58
Yukon	13	13	13	13	14	15	13	12	15	24
Prince Edward Island	5	1	1	1	0.8	0.8	0.6	3	3	1
Total	2,409	2,493	2,582	2,851	3,050	3,391	3,745	3,980r	4,398	4,763

p Preliminary; r Revised.

TABLE 8

Canada, Percentage Contribution of Provinces to Total Value of Mineral Production, 1959-68

	1959	1960	1961	1962	1963	1964	1965	1966r	1967	1968p
Ontario	40.3	39.4	36.6	32.0	28.7	26.7	26.5	24.1	27.2	28.3
Alberta	15.6	15.9	18.3	19.9	21.9	21.7	21.2	21.3	22.1	22.9
Quebec	18.3	17.9	17.6	18.2	17.7	20.2	19.1	19.3	16.7	15.4
British Columbia	6.6	7.5	7.3	8.2	8.6	7.9	7.5	8.3	8.6	8.3
Saskatchewan	8.7	8.5	8.4	8.4	8.9	8.6	8.8	8.8	8.2	7.8
Newfoundland	3.0	3.5	3.6	3.6	4.5	5.4	5.5	6.1	6.1	6.8
Manitoba	2.3	2.4	3.9	5.6	5.6	5.1	4.9	4.5	4.2	4.4
Northwest Territories	1.1	1.1	0.7	0.6	0.5	0.5	2.1	2.8	2.7	2.6
New Brunswick	0.8	0.7	0.7	0.8	0.9	1.4	2.2	2.3	2.1	1.8
Nova Scotia	2.6	2.6	2.4	2.2	2.2	2.0	1.9	2.1	1.8	1.2
Yukon	0.5	0.5	0.5	0.5	0.5	0.5	0.3	0.3	0.3	0.5
Prince Edward Island	0.2	0.05	0.02	0.02	0.03	0.02	0.02	0.1	0.05	0.03
Total Canada	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 9
Canada, Production of Leading Minerals

	Unit of Measure	Nfld.	P.E.I.	N.S.	N.B.	Quebec	Ontario
Petroleum, crude	bbl	–	–	–	7,648	–	1,154,028
	$	–	–	–	23,353	–	3,289,974
Copper	st	21,861	–	91	8,060	156,113	288,485
	$	21,029,782	–	87,584	7,754,122	150,180,715	277,522,347
Iron Ore	st	20,917,979	–	–	–	15,607,238	10,773,511
	$	262,501,000	–	–	–	145,133,551	127,923,747
Nickel	st	–	–	–	–	887	203,179
	$	–	–	–	–	1,800,116	403,563,549
Zinc	st	35,750	–	72	133,303	212,372	345,554
	$	10,081,682	–	20,135	37,591,486	59,888,709	97,446,411
Natural gas	mcf	–	–	–	112,967	137,573	11,974,385
	$	–	–	–	56,484	20,636	4,670,010
Asbestos	st	69,000	–	–	–	1,368,811	19,200
	$	11,900,000	–	–	–	151,770,454	2,282,600
Cement	st	95,000	–	223,000	140,000	2,400,961	3,187,000
	$	1,411,985	–	4,040,000	2,520,000	41,073,140	57,555,500
Sand and Gravel	st	2,633,889	499,724	5,154,461	5,168,697	35,317,769	93,645,523
	$	2,260,819	887,187	2,719,699	2,973,105	18,531,010	57,777,676
Gold	oz	22,757	–	–	1,859	772,853	1,361,469
	$	858,166	–	–	70,103	29,144,287	51,340,996
Silver	oz	1,110,000	–	246,136	3,459,000	4,015,827	22,591,106
	$	2,572,980	–	570,543	8,017,962	9,308,687	52,366,184
Stone	st	456,854	575,400	585,748	1,875,376	35,684,994	28,443,907
	$	661,854	545,000	1,700,300	2,483,865	42,217,962	36,500,930
Lead	st	22,358	–	1,607	52,948	2,991	14,036
	$	6,045,784	–	434,507	14,317,306	808,915	3,795,129
Sulphur, elemental	st	–	–	–	–	–	112
	$	–	–	–	–	–	5,000
Potash (K_2O)	st	–	–	–	–	–	–
	$	–	–	–	–	–	–
Coal	st	–	–	3,130,332	797,234	–	–
	$	–	–	30,400,187	7,370,119	–	–
Uranium (U_3O_8)	lb	–	–	–	–	–	5,400,000
	$	–	–	–	–	–	35,482,000
Clay products	$	144,885	–	1,448,563	574,963	5,835,851	28,747,913
Platinum metals	oz	–	–	–	–	–	463,200
	$	–	–	–	–	–	43,939,000
Molybdenum	lb	–	–	–	–	2,725,848	–
	$	–	–	–	–	4,842,795	–
Salt	st	–	–	500,740	–	–	4,149,214
	$	–	–	6,123,542	–	–	21,781,781
Titanium dioxide	st	–	–	–	–	. .	–
	$	–	–	–	–	24,574,000	–
Lime	st	–	–	–	2,610	325,615	915,744
	$	–	–	–	69,410	3,777,536	11,118,618
Cadmium	lb	–	–	–	71,250	337,027	2,492,730
	$	–	–	–	188,812	891,952	6,976,855
Gypsum	st	454,955	–	4,451,500	86,392	–	742,366
	$	1,091,392	–	8,961,950	175,000	–	1,745,400
Total leading minerals	$	320,560,329	1,432,187	56,507,010	84,186,090	689,800,316	1,325,831,620
Total all minerals	$	323,663,829	1,432,187	57,970,762	87,077,572	731,346,843	1,349,785,578
Leading minerals as % of all minerals		99.0	100.0	97.5	96.7	94.3	98.2

– Nil; . . Not available; [p]Preliminary.

by Provinces and Territories 1968[p]

Manitoba	Sask.	Alberta	B.C.	Y.T.	N.W.T.	Total Canada
6,203,745	91,879,781	257,186,578	22,203,227	–	751,592	379,386,599
15,562,275	211,282,702	656,149,366	50,622,363	–	864,325	937,794,358
33,276	22,734	–	82,424	5,983	1,049	620,076
32,011,363	21,870,600	–	79,292,405	5,755,550	946,108	596,450,576
–	–	–	2,074,601	–	–	49,373,329
–	–	–	20,354,221	–	–	555,912,519
57,893	217	–	1,672	–	–	263,848
117,805,290	441,955	–	3,394,160	–	–	527,005,070
44,603	30,270	–	149,476	2,430	215,000	1,168,830
12,577,992	8,536,126	–	42,152,396	685,260	60,630,000	329,610,197
–	56,780,953	1,363,394,713	260,344,311	–	42,602	1,692,787,504
–	7,320,520	191,832,623	28,637,874	–	18,006	232,556,153
–	–	–	75,000	64,000	–	1,596,011
–	–	–	13,875,000	10,240,000	–	190,068,054
461,533	294,655	799,800	677,203	–	–	8,279,152
9,895,000	8,825,000	16,193,000	15,027,424	–	–	156,541,049
10,229,546	9,287,792	13,052,578	23,538,608	–	–	198,528,587
6,815,263	5,455,462	11,687,734	18,992,836	–	–	128,100,791
44,451	45,249	100	127,626	24,957	347,012	2,748,333
1,676,247	1,706,340	3,771	4,812,776	941,128	13,085,822	103,639,636
646,289	657,781	10	6,977,705	2,061,534	3,855,967	45,621,355
1,498,098	1,524,736	23	16,174,320	4,778,635	8,938,132	105,750,300
1,795,597	15	142,037	5,123,957	–	–	74,618,885
3,414,753	100	620,300	8,268,687	–	–	96,413,751
1,637	2,352	–	115,433	3,518	130,000	346,880
442,649	635,981	–	31,213,027	951,117	35,152,000	93,796,415
5,264	29,864	2,504,001	46,272	–	–	2,585,513
176,000	1,053,498	78,387,185	1,655,020	–	–	81,276,703
–	2,890,733	–	–	–	–	2,890,733
–	73,950,000	–	–	–	–	73,950,000
–	2,250,219	3,913,801	863,194	–	–	10,954,780
–	4,164,841	12,698,169	6,464,142	–	–	61,097,458
–	2,000,000	–	–	–	–	7,400,000
–	10,000,000	–	–	–	–	45,482,000
464,874	1,228,010	4,440,874	3,378,550	–	–	46,264,483
..	1,200	–	–	–	–	464,400
..	86,124	–	–	–	–	44,025,124
–	–	–	19,575,122	–	–	22,300,970
–	–	–	35,481,522	–	–	40,324,317
29,788	80,000	127,892	–	–	–	4,887,634
722,663	1,304,000	1,976,000	–	–	–	31,907,986
–	–	–	–	–	–	..
–	–	–	–	–	–	24,574,000
50,976	–	71,043	–	–	–	1,365,988
854,600	–	1,266,364	–	–	–	17,086,528
213,251	98,190	–	1,274,719	50,750	900,000	5,437,917
607,765	279,840	–	3,632,949	144,638	2,565,000	15,287,811
159,980	–	–	250,000	–	–	6,145,193
485,000	–	–	700,000	–	–	13,158,742
205,009,832	359,665,835	975,255,409	384,129,672	23,496,328	122,199,393	4,548,074,021
208,276,090	370,440,498	1,090,826,809	396,703,669	23,496,328	122,199,393	4,763,219,558
98.4	97.1	89.4	96.8	100.0	100.0	95.5

TABLE 10

Canada, World Role as a Producer

	Year		World Production	1
Nickel (mine production)	1968	st % of world total	553,000	Canada 263,848 48
Zinc (mine production)	1968	st % of world total	5,109,037	Canada 1,168,830 23
Asbestos	1967	st % of world total	3,094,784	Canada 1,452,104 47
Potash (K_2O equivalent)	1968	000 st % of world total	17,140	U.S.S.R. 3,472 20
Uranium (U_3O_8 concentrates) (Excludes communist nations)	1967	st % of world total	17,043	U.S.A. 9,125 54
Molybdenum (Excludes communist nations)	1967	st % of world total	62,607	U.S.A. 44,465 71
Titanium concentrate (Ilmenite)	1967	st % of world total	2,959,965	U.S.A. 935,091 32
Silver (mine production)	1967	Troy oz % of world total	260,677,487	Mexico 37,939,498 15
Cadmium (smelter production)	1968	000 lb % of world total	34,376	U.S.A. 10,651 31
Gypsum	1967	000 st % of world total	52,145	U.S.A. 9,393 18
Lead (mine production)	1968	st % of world total	3,308,994	U.S.S.R. 529,000 16
Aluminum (primary metal)	1968	st % of world total	9,042,120	U.S.A. 3,255,041 36
Platinum group metals (mine production)	1968	Troy oz % of world total	3,415,325	U.S.S.R. 2,000,000 59
Cobalt (mine production)	1967	st % of world total	19,895	Congo 10,709 54
Gold (mine production)	1967	Troy oz % of world total	45,634,296	Rep. of S. Africa 30,532,880 67
Iron ore	1968	000 lt % of world total	658,328	U.S.S.R. 174,205 27
Magnesium	1968	st % of world total	207,089	U.S.A. 98,375 48
Copper (mine production)	1968	st % of world total	5,994,862	U.S.A. 1,203,000 20

[e] Estimated.

of Certain Important Minerals,1967-68

Rank of Six Leading Countries with % of World Total				
2	3	4	5	6
U.S.S.R. 114,000 21	New Caledonia 88,100 16	Cuba 40,000 7	U.S.A. 15,154 3	Republic of South Africa 6,500 1
U.S.S.R. 565,000 11	U.S.A. 526,428 10	Australia 357,576 7	Peru 340,720 7	Japan 291,300 6
U.S.S.R. 847,676 27	Rep. of S. Africa 268,482 9	China 165,000[e] 5	U.S.A. 123,189 4	Italy 111,402 3
Canada 2,891 17	U.S.A. 2,722 16	West Germany 2,447 14	East Germany 2,425 14	France 1,895 11
Canada 3,738 22	Rep. of S. Africa 3,300 19	Gabon 500 3	Australia 300 2	Sweden 50 0.3
Canada 10,688 17	Chile 5,376 9	Peru 1,018 2	South Korea 306 0.5	Norway 285 0.5
Canada 602,455 20	Australia 600,000 20	Norway 407,855 14	Malaysia 140,000 5	Finland 137,789 5
Canada 36,315,189 14	Peru 35,869,829 14	U.S.S.R. 35,000,000 13	U.S.A. 32,118,694 12	Australia 19,765,000 8
Canada 5,438 16	U.S.S.R. 4,850 14	Japan 4,500 13	Belgium 1,898 6	France 1,246 4
France 5,622 11	**Canada** 5,175 10	U.S.S.R. 5,171 10	U.K. 5,063 9	Italy 3,638 7
Australia 415,227 13	**Canada** 361,128 11	U.S.A. 354,166 11	Mexico 185,708 6	Peru 184,958 6
U.S.S.R. 1,350,000 15	**Canada** 979,171 11	Japan 531,200 6	Norway 518,169 6	France 403,159 5
Rep. of S. Africa 914,000 27	**Canada** 464,400 14	Columbia 15,076 0.4	U.S.A. 14,793 0.4	Japan 6,806 0.2
Morocco 2,130 11	**Canada** 1,802 9	Zambia 1,604 8	U.S.S.R. 1,500 8	Finland 1,350 7
U.S.S.R. 5,700,000 13	**Canada** 2,986,268 7	U.S.A. 1,584,187 4	Ghana 762,609 2	Australia 627,171 1
U.S.A. 85,860 13	France 54,902 8	**Canada** 44,083 7	Sweden 31,882 5	China 31,494 5
U.S.S.R. 45,000 22	Norway 34,500 17	**Canada** 9,878 5	Italy 7,267 4	Japan 6,236 3
U.S.S.R. 905,000 15	Zambia 804,134 13	Chile 725,559 12	**Canada** 620,076 10	Rep. of Congo 357,700 6

TABLE 11

Canada, Census Value Added, Commodity Producing Industries
1962-67
($ millions)

	1962	1963	1964	1965	1966	1967
Primary Industries						
Agriculture	2,353	2,592	2,394	2,614	3,271	2,729
Forestry	702	492	557	603	673	688
Fishing	131	130	149	160	176	164
Trapping	10	12	13	12	14	10
Mining*	1,868	2,023	2,291	2,476	2,610	2,910
Electric Power	876	912	970	1,036	1,132	1,234
Total	5,940	6,161	6,374	6,901	7,876	7,735
Secondary Industries						
Manufacturing	11,430	12,273	13,536	14,928	16,352	17,005
Construction	2,900	3,065	3,391	3,987	4,844	5,148
Total	14,330	15,338	16,927	18,915	21,196	22,153
Grand total	20,270	21,499	23,301	25,816	29,072	29,888

Note: Data revised to conform with revised standard industrial classification and new establishment concept.

*Excludes cement, lime and clay and clay products (from domestic clays) manufacture. These industries in the above table are included under manufacturing.

TABLE 12

Canada, Exports of Crude Minerals and Fabricated Mineral Products, by Main Groups, 1967 and 1968
($ millions)

	1967	1968	Increase or decrease $ millions	%
Ferrous				
Crude material	398.2	458.3	+ 60.1	+15.1
Fabricated material	286.0	384.9	+ 98.9	+34.6
Total	684.2	843.2	+159.0	+23.2
Nonferrous				
Crude material	617.7	803.9	+186.2	+30.1
Fabricated material*	1,170.0	1,297.5	+127.5	+10.9
Total	1,787.7	2,101.4	+313.7	+17.5
Nonmetals				
Crude material	274.7	320.7	+ 46.0	+16.7
Fabricated material	146.1	166.2	+ 20.1	+13.8
Total	420.8	486.9	+ 66.1	+15.7
Mineral fuels				
Crude material	537.1	621.2	+ 84.1	+15.7
Fabricated material	39.6	50.4	+ 10.8	+27.3
Total	576.7	671.6	+ 94.9	+16.5
Total mineral and products				
Crude material	1,827.7	2,204.1	+376.4	+20.6
Fabricated material	1,641.7	1,899.0	+257.3	+15.7
Total	3,469.4	4,103.1	+633.7	+18.3

*Includes gold.
Note: Crude materials include materials in primary stages of processing such as ores, metallic concentrates, milled asbestos, etc. Metallic waste and scrap are also included. Fabricated materials include all materials of mineral origin which have been fabricated to such an extent that they can be incorporated into a structure, machine, etc. They are products not useful in themselves, but are for incorporation into end products.

TABLE 13

Canada, Value of Imports of Crude Minerals and Fabricated Mineral Products, by Main Groups, 1967 and 1968
($ millions)

	1967	1968	Increase or decrease $ millions	%
Ferrous				
Crude material	48.0	48.7	+ 0.7	+ 1.5
Fabricated material	551.0	537.1	− 13.9	− 2.5
Total	599.0	585.8	− 13.2	− 2.2
Nonferrous*				
Crude material	131.9	172.5	+ 40.6	+ 30.8
Fabricated material	269.0	298.2	+ 29.2	+ 10.9
Total	400.9	470.7	+ 69.8	+ 17.4
Nonmetals				
Crude material	66.2	63.6	− 2.6	− 3.9
Fabricated material	149.3	141.2	− 8.1	− 5.4
Total	215.5	204.8	− 10.7	− 5.0
Mineral fuels				
Crude material	521.8	568.8	+ 47.0	+ 9.0
Fabricated material	198.4	216.0	+ 17.6	+ 8.9
Total	720.2	784.8	+ 64.6	+ 9.0
Total minerals and products				
Crude material	767.9	853.6	+ 85.7	+ 11.2
Fabricated material	1,167.7	1,192.5	+ 24.8	+ 2.1
Total	1,935.6	2,046.1	+ 110.5	+ 5.7

*Includes gold, refined and unrefined.
Note: See note, bottom of Table 12, in respect to crude and fabricated materials.

TABLE 14

Canada, Value of Exports of Crude Minerals and Fabricated Mineral Products in Relation to Total Export Trade 1967 and 1968

	1967		1968	
	$ Millions	% of Total	$ Millions	% of Total
Crude material	1,827.7	16.4	2,204.1	16.7
Fabricated material*	1,641.7	14.8	1,899.0	14.3
Total	3,469.4	31.2	4,103.1	31.0
Total exports* all products	11,111.6[r]	100.0	13,220.3	100.0

*Includes gold refined and unrefined, which are considered non-trade items and not included in domestic exports.
[r] Revised from previously published figure.
Note: See note, bottom of Table 12, in respect to crude and fabricated minerals.

TABLE 15

Canada, Value of Imports of Crude Minerals and Fabricated Mineral Products in Relation to Total Import Trade 1967 and 1968

	1967		1968	
	$ Millions	% of Total	$ Millions	% of Total
Crude material	767.9	6.9	853.5	6.9
Fabricated material*	1,167.7	10.5	1,192.6	9.6
Total	1,935.6	17.4	2,046.1	16.5
Total imports* all products	11,075.2[r]	100.0	12,366.7	100.0

*Includes gold, refined and unrefined.
[r] Revised from previously published figure.
Note: See note, bottom of Table 12, in respect to crude and fabricated minerals.

TABLE 16

Canada, Value of Exports of Crude Minerals and Fabricated Mineral Products by Main Groups and Destination, 1968
($ millions)

	Britain	United States	Other Countries	Total
Ferrous materials and products	56.0	649.0	138.1	843.1
Nonferrous* materials and products	470.5	921.1	709.8	2,101.4
Nonmetallic mineral materials and products	21.8	252.8	212.3	486.9
Mineral fuels, materials and products	0.6	648.8	22.2	671.6
Total	548.9	2,471.7	1,082.4	4,103.0
Percentage	13.4	60.2	26.4	100.0

* Includes gold, refined and unrefined.
Note: See note, bottom of Table 12, in respect to crude and fabricated minerals.

TABLE 17

Canada, Value of Imports of Crude Minerals and Fabricated Mineral Products by Main Groups and Destination, 1968
($ millions)

	Britain	United States	Other Countries	Total
Ferrous materials and products	44.6	394.4	146.8	585.8
Nonferrous* materials and products	34.9	282.8	153.0	470.7
Nonmetallic mineral materials and products	10.9	146.4	47.5	204.8
Mineral fuels, materials and products	3.8	266.8	514.2	784.8
Total	94.2	1,090.4	861.5	2,046.1
Percentage	4.6	53.3	42.1	100.0

* Includes gold, refined and unrefined.
Note: See note, bottom of Table 12, in respect to crude and fabricated minerals.

TABLE 18

Canada, Value of Exports of Crude Minerals and Fabricated Mineral Products, by Commodity and Destination, 1968
($ 000)

	U.S.A.	Britain	Other (*) E.F.T.A. Countries	E.E.C. (**) Countries	Japan	Other Countries	Total
Iron Ore	339,334	37,586	–	41,563	19,479	5,240	443,202
Primary ferrous metals	63,394	7,556	128	6,339	5,481	4,098	86,996
Aluminum	253,073	73,327	1,792	25,487	46,900	62,105	462,684
Copper	206,077	124,702	37,993	78,278	123,763	40,747	611,560
Lead	21,507	11,655	441	13,249	6,384	1,915	55,151
Nickel	242,257	143,299	2,005	19,080	14,027	85,796	506,464
Zinc	74,258	27,578	3,733	40,470	12,879	18,314	177,232
Molybdenum	323	12,690	2,302	16,846	10,306	1,208	43,675
Uranium	3	26,064	–	–	–	–	26,067
Asbestos	71,785	17,045	6,145	40,311	11,738	49,065	196,089
Fuels	648,825	354	562	2,024	19,573	257	671,595
All other minerals (†)	550,896	67,001	5,571	51,412	24,543	122,897	822,320
Total	2,471,732	548,857	60,672	335,059	295,073	391,642	4,103,035

(*) Other European Free Trade Countries: Norway, Sweden, Denmark, Switzerland, Austria and Portugal; (**) European Economic Community (Common Market) Countries: France, West Germany, Italy, Belgium, Luxembourg and the Netherlands; (†) Includes gold, refined and unrefined.
– Nil.
Note: See note, bottom of Table 12, in respect to crude and fabricated materials.

TABLE 19

Canada, Reported Consumption of Minerals, and Relation to Production, 1967

Mineral	Unit of Measure	Consumption	Production[1]	Consumption as % of Production
Metals				
Aluminum	st	217,494	975,439	22.3
Antimony	lb	1,190,179	1,267,686	93.9
Bismuth	lb	47,894	668,476	7.2
Cadmium	lb	154,761	4,836,317	3.2
Chromium (chromite)	st	70,549	–	. .
Cobalt	lb	293,086	3,603,773	8.1
Copper	st	224,400[2]	613,314	36.6
Lead	st	59,422[3]	317,963	18.7
Magnesium	st	5,054	8,887	56.9
Manganese ore	st	137,395	–	. .
Mercury	lb	245,121	–	. .
Molybdenum (Mo content)	lb	1,430,895	21,376,766	6.7
Nickel	st	8,767	248,647	3.5
Selenium	lb	21,017	724,573	2.9
Silver	oz	14,576,608	36,315,189	40.1
Tellurium	lb	1,005[2]	73,219	1.4
Tin	lt	4,812	196	2,455.1
Tungsten (W content)	lb	891,411	. .	. .
Zinc	st	108,114[3]	1,111,453	9.7
Nonmetals				
Barite	st	19,124[r]	172,270	11.1
Feldspar	st	9,021	10,394	86.8
Fluorspar	st	155,349	. .	. .
Mica	lb	2,758,000	. .	. .
Nepheline syenite	st	50,286	401,601	12.5
Phosphate rock	st	2,275,067	–	. .
Potash (muriate of potash)	st	194,681	2,383,253	8.2
Sodium sulphate	st	284,645	428,316	66.5
Sulphur, elemental	st	743,278	2,499,205	29.7
Talc, etc.	st	33,893	60,665	55.9
Fuels				
Coal	st	25,878,083	11,122,935	232.7
Natural gas	Mcf	698,223,437[4]	1,471,724,535	47.4
Petroleum, crude	bbl	387,718,614[5]	351,292,332	110.4

[1] Production for metals, in most cases, refers to production in all forms. This includes the recoverable metal content of ores, concentrates, matte, etc., exported and the metal content of primary products recoverable at domestic smelters and refineries. Production of nonmetals refers to producers' shipments. For fuels, production is equivalent to actual output less waste.
[2] Producers' domestic shipments.
[3] Producers' domestic shipments, primary refined metal.
[4] Sales; [5] Refinery receipts.
–Nil; . . Not available or not applicable; [r]Revised.

TABLE 20

Canada, Reported Consumption of Minerals, and Relation to Production, 1968

Mineral	Unit of Measure	Consumption	Production[1]	Consumption as % of Production
Metals				
Aluminum	st	239,637	994,457	24.1
Antimony	lb	1,169,631	1,124,000	104.1
Bismuth	lb	59,346	639,866	9.3
Cadmium	lb	125,245	5,437,917	2.3
Chromium (chromite)	st	77,075	–	. .
Cobalt	lb	358,098	3,978,656	9.0
Copper	st	253,200[2]	620,076	40.8
Lead	st	66,477[3]	346,880	19.2
Magnesium	st	5,654	9,878	57.2
Manganese ore	st	124,904	–	. .
Mercury	lb	327,939	. .	. .
Molybdenum (Mo content)	lb	1,543,432	22,300,970	6.9
Nickel	st	11,239	263,848	4.3
Selenium	lb	21,440	709,200	3.0
Silver	oz	13,598,358	45,621,355	29.8
Tellurium	lb	2,405[2]	65,193	3.7
Tin	lt	4,251	150	2,834.0
Tungsten (W content)	lb	1,181,541	. .	. .
Zinc	st	124,930[3]	1,168,830	10.7
Nonmetals				
Barite	st	20,000[e]	137,699	14.5
Feldspar	st	7,741	10,708	72.2
Fluorspar	st	178,903	. .	. .
Mica	lb	3,944,000	. .	. .
Nepheline Syenite	st	48,504	425,463	11.4
Phosphate rock	st	2,234,259	–	. .
Potash (muriate of potash)	st	161,899	2,890,733	5.6
Sodium sulphate	st	318,408	469,076	67.9
Sulphur, elemental	st	731,198	2,585,513	28.3
Talc, etc.	st	33,005	77,300	42.7
Fuels				
Coal	st	26,924,740	10,954,780	245.8
Natural gas	Mcf	765,786,814[4]	1,692,787,504	45.2
Petroleum, crude	bbl	413,471,510[5]	379,386,599	109.0

[1] Production for metals, in most cases, refers to production in all forms. This includes the recoverable metal content of ores, concentrates, matte, etc., exported and the metal content of primary products recoverable at domestic smelters and refineries. Production of nonmetals refers to producers' shipments. For fuels, production is equivalent to actual output less waste.
[2] Producers' domestic shipments.
[3] Producers' domestic shipments, primary refined metal.
[4] Sales: [5] Refinery receipts.
– Nil; . . Not available or not applicable; [e] Estimated.

TABLE 21

Canada, Apparent Consumption of Minerals
and Its Relation to Production, 1967

Mineral	Unit of Measure	Apparent Consumption*	Production**	Consumption as % of Production
Asbestos	st	117,353	1,452,104	8.1
Cement	st	7,711,053	7,994,954	96.4
Gypsum	st	1,373,494	5,175,384	26.5
Iron ore	lt	8,777,888	37,783,749	23.2
Lime	st	1,354,888	1,422,899	95.2
Quartz (silica)	st	3,507,141	2,610,740	134.3
Salt	st	4,320,000[e]	5,361,463	80.5

* Production plus imports and less exports. Consumption of these commodities as reported by consumers is not readily available.
** Producers' shipments.
[e] Estimated.

TABLE 22

Canada, Apparent Consumption of Minerals
and Its Relation to Production, 1968

Mineral	Unit of Measure	Apparent Consumption*	Production**	Consumption as % of Production
Asbestos	st	142,293	1,596,011	8.9
Cement	st	7,964,145	8,279,152	96.2
Gypsum	st	1,750,650	6,145,193	28.5
Iron ore	lt	10,822,198	44,083,329	24.5
Lime	st	1,305,494	1,365,988	95.6
Quartz (silica)	st	3,664,356	2,621,326	139.8
Salt	st	4,300,000[e]	4,887,634	88.0

* Production plus imports and less exports. Consumption of these commodities as reported by consumer is not readily available.
** Producers' shipments.
[e] Estimated.

TABLE 23

Canada, Domestic Consumption of Principal Refined Metals[1] in Relation to Production[2], 1959-68

	Unit of Measure	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968
Copper											
Domestic consumption[3]	st	129,973	117,637	141,808	151,525	169,750	202,225	224,684	262,557	224,398	253,198
Production	st	365,366	417,029	406,359	382,862	380,075	407,942	434,133	433,921	500,020	524,956
% Consumption of production		35.6	28.2	34.9	39.6	44.7	49.6	51.8	60.5	44.9	48.2
Zinc											
Domestic consumption[4]	st	64,788	55,803	60,878	65,320	73,653	88,494	93,796	107,052	109,983[r]	124,930
Production	st	255,306	260,968	268,007	280,158	284,021	337,728	358,498	382,612	405,098	426,933
% Consumption of production		25.4	21.4	22.7	23.3	25.9	26.2	26.2	28.0	27.1	29.3
Lead											
Domestic consumption	st	65,935	72,087	73,418	77,286	77,958	82,736	90,168	96,683	59,422[6]	66,477[6]
Production	st	135,296	158,510	171,833	152,217	155,000	151,372	186,484	184,871	194,814	202,100
% Consumption of production		48.7	45.5	42.7	50.8	50.3	54.7	48.4	52.3	30.5	32.9
Aluminum											
Domestic consumption[5]	st	114,344	120,831	135,575	151,893	166,833	172,443	213,094	243,065	217,494[r]	239,637
Production	st	593,630	762,012	663,173	690,297	719,390	842,640	830,505	889,915	975,439	994,457
% Consumption of production		19.3	15.9	20.4	22.0	23.2	20.5	25.7	27.3	22.3	24.1

[1] Refined metal of primary and secondary origin. [2] Refined metal from all sources, including metal derived from secondary materials at primary refineries. [3] Producers' domestic shipments. [4] Primary refined zinc only. [5] Producers' domestic shipments; primary and secondary aluminum consumption. [6] Producers' domestic shipments, primary refined metal.
[r] Revised.

TABLE 24

Annual Averages of Prices of Main Minerals* 1967 and 1968

	Unit of Measure	Average		Increase or Decrease	
		1967	1968	Cents or Dollars	%
Aluminum ingot 99.5%	cents/lb	25.000	25.500	+ 0.500	+ 2.0
Antimony, RMM f.o.b. Loredo, Texas	cents/lb	44.000	47.500	+ 3.500	+ 8.0
Bismuth, ton lots delivered	$/lb	4.000	4.000	–	–
Cadmium	cents/lb	264.722	270.000	+ 5.278	+ 2.0
Calcium, ton lots, crowns	$/lb	0.95	0.95	–	–
Chromium metal, 98.5%, 0.5% C	$/lb	0.97	0.96	– 0.01	– 1.0
Cobalt metal, 500 lb. lots	$/lb	1.850	1.850	–	–
Copper, U.S. domestic, f.o.b. refinery	cents/lb	38.226**	41.847†	+ 3.621	+ 9.5
Gold, Canadian dollars	$/troy oz	37.75	37.71	– 0.04	– 0.1
Iron ore, 51.5% Fe, lower lake ports					
Bessemer					
Mesabi	$/lt	10.70	10.70	–	–
Old Range	$/lt	10.95	10.95	–	–
Non-Bessemer					
Mesabi	$/lt	10.55	10.55	–	–
Old Range	$/lt	10.80	10.80	–	–
Lead, common, New York	cents/lb	14.000	13.212	– 0.788	– 5.6
Magnesium, ingot	cents/lb	35.250	35.250	–	–
Mercury	$flask (76 lb)	489.355	535.555	+46.200	+ 9.4
Molybdenum metal	$/lb	3.66	3.69	+ 0.03	+ 0.8
Molybdenite, 95% MoS_2 contained Mo	$/lb	1.62	1.62	–	–
Nickel, f.o.b. Port Colborne (duty incl.)	cents/lb	87.774	94.071	+ 6.297	+ 7.2
Platinum	$/troy oz	108.509	114.500	+ 5.991	+ 5.5
Selenium	$/lb	4.50	4.50	–	–
Silver, New York	cents/troy oz	155.012	214.460	+59.448	+38.4
Tin, straits, New York	cents/lb	153.434	148.151	– 5.283	– 3.4
Titanium metal, 500 lb lots 99.3%	$/lb	1.32	1.32	–	–
Titanium ore (ilmenite) 54% TiO_2	$/st	22.50	20.50	– 2.00	– 8.9
Tungsten metal	$/st	2.75	2.75	–	–
Zinc, prime western, East St. Louis	cents/lb	13.843	13.500	– 0.343	– 2.5

*These prices, except for gold are in United States currency and are from *Metals Week*.
**Average 1st eight months. Price quotes suspended September through December.
†Average last nine months. Price quotes suspended January through March.
–Nil.

TABLE 25

Canada, Wholesale Price Indexes of Minerals and Mineral Products, 1958 and 1966-68
(1935-39 = 100)

	1958	1966	1967	1968
Iron and products	252.6	268.0	274.4	276.8
Pig iron	295.3	290.3	289.9	285.1
Rolling mill products	246.6	263.0	264.0	263.0
Pipe and tubing	263.1	294.7	291.4	302.3
Wire	292.2	295.0	300.5	300.3
Scrap iron and steel	276.1	282.7	263.5	252.7
Tinplate and galvanized sheet	239.3	252.5	256.7	257.2
Nonferrous metal and products				
Total (including gold)	167.3	229.9	240.2	250.8
Total (excluding gold)	224.1	328.2	346.6	365.8
Antimony	160.1	362.9	..	398.2
Copper and products	246.5	425.0	446.9	455.0
Lead and products	237.3	312.2	293.2	281.2
Silver	223.2	360.0	425.8	602.8
Tin	179.6	339.1	317.3	305.8
Zinc and products	238.3	329.5	315.9	307.7
Solder	196.4	319.4	304.0	304.8
Nonmetallic minerals and products	188.5	193.7	199.2	206.0
Clay and clay products	248.4	247.1	251.7	259.5
Pottery	180.7	250.8	258.2	261.7
Coal	193.2	201.8	204.7	208.8
Coal tar	237.9	219.5	248.0	270.0
Coke	242.1	268.0	278.0	284.4
Window glass	270.2	342.1	350.3	350.3
Plate glass	217.0	292.1	292.1	292.1
Petroleum products	169.7	160.2	162.3	164.1
Crude oil	..	191.6	191.7	191.6
Gasoline	139.6	127.1	..	127.4
Coal oil	135.4	134.1	134.2	136.5
Asphalt	215.1	197.1	197.7	197.7
Asphalt shingles	148.4	93.3	101.9	115.4
Sulphur	201.8	271.5	342.6	435.3
Plaster	136.3	149.0	163.0	171.7
Lime	211.2	236.2	246.3	259.7
Cement	163.5	177.0	186.4	193.1
Sand and gravel	151.2	143.2	148.6	168.8
Crushed stone	165.0	160.4	162.1	165.3
Building stone	207.6	221.6	232.4	256.3
Asbestos	304.3	326.2	339.0	348.8
General wholesale price index (all products)	227.8	259.5	264.1	269.9

. . Not available.

TABLE 26

Canada, General Wholesale Price Index and Wholesale Price Indexes of Mineral and Nonmineral Products Industries, 1944-1968

(1935-39 = 100)

	Mineral Products Industries			Nonmineral Products Industries					
	Iron Products	Nonferrous Metal Products	Nonmetallic Mineral Products	Vegetable Products	Animal Products	Textile Products	Wood Products	Chemical Products	General Wholesale Price Index
1944	117.8	107.8	114.3	129.1	146.6	130.7	151.6	124.9	130.6
1945	117.9	107.6	113.5	131.6	150.0	130.8	154.9	124.0	132.1
1946	127.4	108.0	114.5	134.2	160.2	137.9	172.1	120.3	138.9
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
1668	276.8	250.8	206.0	230.8	294.6	256.5	367.9	213.7	269.9

TABLE 27

Canada, Industry Selling Price Indexes Mineral Products Industries, 1965-68
(1956=100)

	1965	1966	1967	1968
Iron and steel products industries				
Agricultural implements industry	117.4	121.5	123.5	128.0
Hardware, tools and cutlery industry	120.2	124.7	129.1	132.3
Heating and cooking apparatus industry	93.5	92.2	93.7	96.2
Machinery, household, office and store industry	99.9	100.1	101.4	103.2
Castings, iron industry	110.6	113.8	117.5	118.6
Pig iron industry	104.1	104.3	104.3	102.9
Steel ingots and castings industry	122.2	122.4	128.0	128.2
Rolled iron and steel products industry	108.6	109.4	111.2	111.0
Wire and wire goods industry	109.6	110.6	111.4	112.4
Nonferrous metal products industries				
Aluminum products industry	110.6	111.7	112.8	113.1
Brass and copper products industry	100.8	115.7	120.7	124.1
Jewellery and silverware industry	133.2	138.6	157.6	187.3
Nonferrous metal smelting and refining industry	112.9	114.9	119.2	122.9
White metal alloys industry	118.7	120.1	116.6	118.1
Nonmetallic mineral products industries				
Abrasives, artificial, industry	115.9	119.4	123.0	123.0
Cement, hydraulic, industry	115.4	121.8	128.2	133.0
Clay products from imported clay industry	112.1	115.9	117.5	120.8
Glass and glass products industry	109.3	111.9	114.2	117.0
Lime industry	114.6	116.1	117.6	117.7
Gypsum products industry	107.9	109.2	114.3	118.3
Concrete products industry	105.5	110.9	114.2	116.3
Clay products from domestic clay industry	111.0	114.3	118.7	121.4
Coke and gas products industry	112.3	113.3	116.6	117.5
Petroleum refining and products industry	93.2	93.5	94.2	95.7
Lubricating oils and greases industry	118.2	120.9	124.8	132.9
Fertilizers industry	107.5	108.6	111.5	113.1

Industry selling price indexes are wholesale price indexes organized according to the standard industrial classification.

TABLE 28

Canada, Principal Statistics of the Mineral Industry, by Sectors, 1966

	MINERAL ACTIVITY								TOTAL ACTIVITY		
	Establishments Number	Production and Related Workers			Cost of Fuel and Electricity $ 000	Cost of Materials and Supplies $ 000	Value of Production $ 000	Value Added $ 000	Employees		Value Added $ 000
		Number	Man hours paid 000	Wages $ 000					Number	Salaries & Wages $ 000	
Metallic											
Placer gold	22	105	260	745	93	344	1,775	1,339	124	936	1,628
Gold quartz	54	9,758	20,834	46,905	6,348	32,914	132,290	93,028	11,560	58,133	94,123
Copper-gold-silver	43	9,986	21,502	57,442	9,535	121,532	408,082	277,015	12,467	73,461	282,415
Silver-cobalt	8	437	946	1,966	272	1,429	7,417	5,715	545	2,599	5,804
Silver-lead-zinc	24	4,604	9,960	26,993	5,905	89,070	263,217	158,242	5,811	35,414	159,601
Nickel-copper	10	13,225	25,482	76,998	4,781	208,067	526,950	314,102	15,184	94,069	315,901
Iron	18	7,339	16,430	55,120	26,256	101,690	378,340	250,393	11,464	87,165	251,494
Misc. metal mines	14	2,850	6,199	18,309	4,147	20,215	102,628	78,266	3,694	24,046	78,859
Sales and Head Offices	–	–	–	–	–	–	–	–	849	9,319	1,170
Total	193	48,304	101,613	284,478	57,337	575,261	1,820,699	1,178,100	61,698	385,142	1,190,995
Industrial Minerals											
Asbestos	10	5,527	12,518	32,632	9,005	26,965	170,664	134,694	6,736	42,229	134,903
Cement	25	2,815	6,277	17,982	24,851	22,560	158,459	111,048	4,053	26,993	110,974
Clay and clay products	81	2,911	6,390	13,551	5,888	7,280	43,662	30,494	3,510	17,362	30,681

Feldspar, quartz and nepheline	12	280	635	1,385	441	1,480	8,137	6,217	367	1,920	6,297
Gypsum	10	471	1,014	2,047	390	1,489	9,432	7,553	585	2,813	7,532
Lime	13	626	1,408	3,119	2,782	2,439	14,046	8,825	785	4,077	9,049
Peat	56	1,107	2,335	3,379	368	2,977	9,773	6,428	1,254	4,257	6,373
Salt	10	828	1,755	4,137	1,316	4,302	23,418	17,800	1,261	6,755	18,062
Sand and gravel	229	2,053	4,814	10,227	3,615	9,810	52,115	38,691	2,611	13,923	39,219
Stone	165	3,040	7,042	15,103	4,549	18,572	71,207	48,085	3,701	19,168	48,661
Talc and soapstone	4	79	179	276	54	274	1,077	748	99	386	746
Misc. nonmetals	14	1,531	3,330	8,798	5,274	10,587	77,291	61,430	2,120	12,581	61,179
Total	629	21,268	47, 697	112,636	58,533	108,735	639,281	472,013	27,082	152,464	473,676
Fuels											
Coal	72	7,628	16,081	35,121	3,577	15,231	81,520	62,711	9,418	44,399	62,956
Petroleum and natural gas	648	3,375	7,027	21,914	12,952	29,159	1,092,535	1,050,424	12,378	95,997	1,059,395
Total	720	11,003	23,108	57,035	16,529	44,390	1,174,055	1,113,135	21,796	140,396	1,122,351
Total Mining Industry	1,542	80,575	172,418	454,149	132,399	728,386	3,634,035	2,763,248	110,576	678,002	2,787,022
Nonferrous smelting and refining	23	24,593	50,896	145,402	62,829	347,280	826,167	416,058	33,237	209,528	433,858
Total Mineral Industry	1,565	105,168	223,314	599,551	195,228	1,075,666	4,460,202	3,179,306	143,813	887,530	3,220,880

Note: Principal statistics contained in this table and also in Tables 29 and 30 have been revised on the basis of the revised industrial classification and new establishment concept.

TABLE 29

Canada, Principal Statistics of the Mining Industry,* 1961-1966

	Mining Activity								Total Activity		
	Establish-ments	Production and Related Workers			Cost of Fuel and Electricity	Cost of Materials and Supply	Value of Production	Value Added	Employees		Value Added
			Manhours paid	Wages						Salaries and Wages	
	number	number	000	$000	$000	$000	$000	$000	number	$000	$000
1961	1,539	79,805	169,281	367,382	85,140	449,043	2,372,002	1,837,821	104,486	520,758	1,862,743
1962	1,574	79,726	168,136	376,066	92,261	492,559	2,573,389	1,988,569	104,615	537,800	2,012,568
1963	1,552	78,016	168,236	377,669	101,160	520,865	2,770,675	2,148,649	103,502	547,751	2,181,370
1964	1,548	78,381	170,622	393,272	109,803	583,143	3,118,200	2,425,253	104,441	571,948	2,459,723
1965	1,586	81,238	176,473	428,500	127,658	678,773	3,428,308	2,621,877	108,979	626,688	2,660,445
1966	1,542	80,575	172,418	454,149	132,399	728,386	3,634,035	2,763,248	110,576	678,002	2,787,022

* Includes cement manufacturing, lime manufactures, clay and clay products (domestic clays)
Includes under "Total Activity" – Sales and Head Offices.

Note: Principal statistics contained in this table and also in Tables 28 and 30 have been revised on the basis of the revised industrial classification and new establishment concept.

TABLE 30

Canada, Principal Statistics of the Nonferrous Smelting and Refining Industries 1961-1966

	Mining Activity								Total Activity		
	Establishments	Production and Related Workers			Cost of Fuel and Electricity	Cost of Materials and Supplies	Value of Production	Value Added	Employees		Value Added
			Manhours paid	Wages						Salaries and Wages	
	number	number	000	$000	$000	$000	$000	$000	number	$000	$000
1961	23	23,508	48,244	118,532	49,927	617,125	617,125	299,183	29,938	159,688	304,891
1962	22	22,621	46,320	116,049	46,697	291,166	649,792	311,929	29,093	158,163	320,373
1963	23	21,553	45,176	112,191	47,055	295,825	639,659	296,779	28,516	159,151	307,247
1964	23	23,239	48,900	126,109	52,988	314,567	718,254	350,699	30,153	174,450	364,749
1965	23	24,382	52,190	139,120	57,950	305,468	770,690	407,272	31,835	192,668	427,651
1966	23	24,593	50,896	145,402	62,829	347,280	826,167	416,058	33,237	209,528	433,858

Note: See bottom of Table 29.

TABLE 31

Canada, Consumption of Fuel and Electricity in the Mineral Industry, 1966

	Unit	Metal Mining	Nonferrous Smelting and Refining	Total	Production of Industrial Minerals*	Production of Crude Mineral Fuels	Total Mineral Industry
Coal and Coke	st	62,978	1,083,500	1,146,478	1,181,824	195	2,328,497
	$000	1,018	17,070	18,088	12,562	4	30,654
Gasoline	gal	3,802,383	1,355,159	5,157,542	9,852,725	798,813	15,809,080
	$000	1,393	389	1,782	3,388	267	5,437
Fuel oil, kerosene and coal oil	gal	136,723,205	95,472,005	232,195,210	127,601,309	2,233,275	362,029,794
	$000	17,409	11,395	28,804	14,208	394	43,406
Liquefied petroleum gas	gal	2,286,624	3,645,057	5,931,681	416,907	43,785	6,392,373
	$000	554	423	977	102	5	1,084
Natural gas	Mcf	2,750,023	15,921,562	18,671,585	33,149,238	–	51,821,823
	$000	1,324	6,044	7,368	10,323	–	17,691
Other fuels	$	392	162	554	850	61	1,465
Total fuels	$000	22,099	35,483	57,573	41,433	731	99,737
Electricity purchased	mil kwh	5,511	7,680	13,191	2,263	831	16,285
	$000	35,247	27,346	62,593	17,100	15,798	95,491
Total value, fuels and electricity purchased	$000	57,337	62,829	120,166	58,533	16,529	195,228
Electricity generated by industry for own use	mil kwh	380	–	380	120	37	537

– Nil.

Note: Statistics in Tables 31, 32 and 33 are on the revised standard industrial classification and new establishment concept.
* Includes also cement industry, lime industry and clay and clay products (from domestic clays) industry.

TABLE 32

Canada, Cost of Fuel and Electricity Used in the Mining Industry*, 1961-66

		1961	1962	1963	1964	1965	1966
Fuel	$ mil	37.8	41.8	46.8	51.0	60.1	64.2
Electricity purchased	mil kwh	5,350	5,658	6,355	7,032	8,443	8,605
	$ mil	47.3	50.5	54.4	58.8	67.6	68.1
Total cost of Fuel and Electricity	$ mil	85.1	92.3	101.2	109.8	127.7	132.3
Electricity Generated for Own Use and for Sale	mil kwh	586.3	654.6	541.6	486.8	524.5	613.2

* Includes cement industry, lime industry and clay and clay products (from domestic clays) industry.
Note: See note bottom of Table 31.

TABLE 33

Canada, Cost of Fuel and Electricity Used in the Nonferrous Smelting and Refining Industry, 1961-66

		1961	1962	1963	1964	1965	1966
Fuel	$ mil	28.1	25.8	24.3	28.4	32.9	35.5
Electricity Purchased	mil kwh	5,389	5,046	6,330	7,189	7,261	7,680
	$ mil	21.8	20.9	22.8	24.6	25.1	27.3
Total Cost of Fuel and Electricity	$ mil	49.9	46.7	47.1	53.0	58.0	62.8

Note: See note bottom of Table 31.

TABLE 34

Canada, Employment, Salaries and Wages in the Mineral Industry
1947, 1952, 1957, 1962, 1966

	1947		1952		1957		1962		1966	
	Employees	$ 000	Employees	$ 000	Employees	$ 000	Employees	$ 000	Employees	$ 000
Metal mining	39,334	96,768	55,338	197,683	62,554	278,533	58,243	306,004	61,698	385,142
Nonferrous smelting and refining	17,449	40,768	24,608	87,964	29,613	134,775	29,093	158,163	33,237	209,528
Industrial minerals*	22,429	39,600	26,141	79,394	31,312	114,340	25,243	116,774	27,082	152,464
Fuels	25,307	52,425	28,029	87,935	21,985	81,954	21,129	115,023	21,796	140,396
Total	104,519	229,561	134,116	452,976	145,464	609,602	133,708	695,964	143,813	887,530
Annual average of salaries and wages		$ 2,196		$ 3,377		$ 4,191		$ 5,205		$ 6,171

* Includes cement, lime and clay and clay products (from domestic clays) manufacture.

TABLE 35

Canada, Number of Wage Earners, Surface, Underground, and Mill, Mining Industry, by Sectors, 1961-66

	1961	1962	1963	1964	1965	1966
Metallics						
Surface	13,076	13,689	13,220	13,703	14,639	14,198
Underground	28,815	27,424	25,838	25,669	26,055	26,009
Mill	6,377	6,601	7,192	7,355	8,356	8,097
Total	48,268	47,714	46,250	46,727	49,050	48,304
Industrial Minerals*						
Surface	9,333	8,770	8,892	8,692	8,885	9,237
Underground	978	968	865	920	1,045	1,117
Mill	9,567	10,729	10,555	10,643	10,950	10,914
Total	19,878	20,467	20,312	20,255	20,880	21,268
Fuels						
Surface	5,321	5,366	5,246	5,255	5,256	5,248
Underground	6,338	6,179	6,208	6,144	6,052	5,755
Mill	–	–	–	–	–	–
Total	11,659	11,545	11,454	11,399	11,308	11,003
Total Mining Industry						
Surface	27,730	27,825	27,358	27,650	28,780	28,683
Underground	36,131	34,571	32,911	32,733	33,152	32,881
Mill	15,944	17,330	17,747	17,998	19,306	19,011
Total	79,805	79,726	78,016	78,381	81,238	80,575

* Includes cement, lime, clay and clay products (from domestic clays) manufacture.

TABLE 36

Canada, Labour Costs in Relation to Tons Mined – Metal Mines, 1946, 1956, 1965, 1966

Type of Metal Mines	Number of Wage Earners	Total Wages	Average Annual Wage	Tons Mined	Average Annual tons mined per Wage Earner	Wage Cost per ton mined
		$ 000	$	000 st	st	$
1966						
Auriferous quartz	9,758	46,905	4,807	11,188	1,147	4.19
Copper-gold-silver	9,986	57,442	5,752	23,086	2,312	2.49
Nickel-copper	13,225	76,998	5,822	21,793	1,648	3.53
Silver-cobalt	437	1,966	4,499	270	618	7.28
Silver-lead-zinc	4,604	26,993	5,863	11,755	2,553	2.30
Iron ore	7,339	55,120	7,511	79,819	10,876	0.69
Miscellaneous	2,850	18,309	6,424	14,883	5,222	1.23
Total	48,199	283,733	5,887	162,794	3,378	1.74
1965						
Auriferous quartz	11,061	49,183	4,446	12,042	1,089	4.08
Copper-gold-silver	9,116	48,157	5,283	20,017	2,196	2.41
Nickel-copper	13,016	73,900	5,678	24,250	1,863	3.05
Silver-cobalt	479	2,112	4,409	279	582	7.57
Silver-lead-zinc	4,486	25,071	5,589	10,139	2,260	2.47
Iron ore	8,168	55,053	6,740	89,155	10,915	0.62
Miscellaneous	2,572	15,092	5,868	10,655	4,143	1.42
Total	48,898	268,568	5,492	166,537	3,406	1.61
1956						
Auriferous quartz	15,165	53,475	3,526	14,589	962	3.66
Copper-gold-silver	8,897	36,017	4,048	10,423	1,172	3.46
Nickel-copper	10,823	48,881	4,516	18,453	1,705	2.65
Silver-cobalt	589	1,970	3,345	205	348	9.61
Silver-lead-zinc	5,320	22,175	4,168	7,651	1,438	2.90
Iron ore	5,526	24,939	4,513	23,951	4,334	1.04
Miscellaneous	3,452	16,120	4,670	2,119	613	7.61
Total	49,772	203,577	4,090	77,391	1,555	2.63
1946						
Auriferous quartz	19,501	39,968	2,050	10,713	549	3.73
Copper-gold-silver	4,383	8,466	1,932	5,009	1,143	1.69
Nickel-copper	4,038	8,844	2,190	8,225	2,037	1.08
Silver-cobalt	224	345	1,540	33	147	10.45
Silver-lead-zinc	2,052	4,940	2,407	2,806	1,367	1.76
Iron ore	–	–	–	–	–	–
Miscellaneous	935	2,047	2,189	2,132	2,280	0.96
Total	31,133	64,610	2,075	28,918	929	2.23

TABLE 37

Canada, Man-hours Worked, Production and Related Workers, Tons of Ore Mined and Rock Quarried, Metal Mines and Industrial Mineral Operations, 1961-66

	Unit	1961	1962	1963	1964	1965	1966
Metal Mines[1]							
Ore mined	million st	99.4	114.3	124.3	141.1	166.5	162.8
Man-hours paid[2]	million	101.2	99.4	99.7	100.7	106.4	101.4
Man-hours paid per ton mined	number	1.02	0.87	0.80	0.71	0.64	0.62
Industrial Mineral Operations[3]							
Ore mined and rock quarried	million st	94.6	100.9	119.0	132.9	144.0	160.3
Man-hours paid[2]	million	21.9	22.8	23.1	24.0	23.2	24.7
Man-hours paid per ton mined	number	0.23	0.22	0.19	0.18	0.16	0.15

[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 38

Canada, Basic Wage Rates in the Metal Mining Industry on October 1, 1967 and 1968

	Gold Mining		Iron Mining		Other Metal Mining	
	1967	1968	1967	1968	1967	1968
	Dollars an Hour					
Underground workers						
Cage and skiptenders	2.00	2.22	..	..	2.69	2.89
Chute blaster	1.93	2.18	..	..	2.84	2.96
Deckman	1.89	2.06	..	..	2.49	2.58
Hoistman	2.10	2.37	..	..	2.89	3.09
Labourer	1.84	2.09	..	..	2.49	2.59
Miner	2.04	2.20	3.16	..	2.73	2.92
Miner's helper	1.82	2.02	..	..	2.28	2.53
Motorman	1.87	2.05	..	..	2.66	2.88
Mucking machine operator	1.92	2.07	..	..	2.64	2.80
Mucker and trammer	1.90	2.06	..	..	2.65	2.82
Timberman	2.04	2.21	..	..	2.77	2.94
Trackman	1.98	2.12	..	..	2.72	2.84
Open-pit workers						
Blaster	..	..	2.92	3.05	..	..
Bulldozer operator	..	..	2.95	3.04	..	..
Driller, machine	..	..	3.03	3.17	..	..
Dump-truck driver	..	..	3.04	3.15	..	..
Oiler	..	..	2.71	2.81	..	..
Shovel operator (power)	..	..	3.44	3.57	..	..
Surface and mill workers						
Blacksmith	..	..	..	..	2.84	3.05
Carpenter, maintenance	2.17	2.35	3.31	3.42	2.82	3.04
Crusher operator	1.96	2.17	2.87	2.99	2.60	2.79
Electrician	2.19	2.43	3.38	3.51	3.10	3.29
Filter operator	..	..	..	..	2.55	2.73
Flotation operator	..	..	..	..	2.68	2.84
Grinding-mill operator	..	..	2.96	3.08	2.60	2.79
Hoistman	..	..	..	..	..	..
Labourer	1.77	2.00	2.51	2.60	2.35	2.51
Machinist, maintenance	2.31	2.40	3.45	3.55	3.29	3.38
Mechanic, diesel	..	..	3.34	3.52	3.00	3.25
Mechanic, maintenance	2.13	2.37	3.29	3.45	2.98	3.19
Millman*	2.05	2.22	..	..	..	..
Pipefitter, maintenance	2.14	2.26	3.31	3.36	2.75	2.97
Solution man	..	..	..	..	2.52	2.74
Steel sharpener	2.10	2.27	..	..	2.68	2.78
Tradesman's helper	1.81	2.08	2.70	2.87	2.55	2.67
Truck driver, light and heavy	1.93	2.12	2.93	3.03	2.66	2.83
Welder, maintenance	2.20	2.42	3.25	3.40	2.94	3.16
Millwright	..	..	3.32	3.36	..	..

* Includes filter operator, grinding mill operator (ball-mill operator, rod-mill operator, tubeman) and solution man.
.. Not available or not applicable.

TABLE 39

Canada, Index Numbers of Average Wage Rates* by Industries, 1963-68
(1961 = 100)

	1963	1964	1965	1966	1967	1968
Logging	110.1	117.5	126.4	140.2	156.0	162.5
Metal mining	107.0	109.6	113.3	122.7	130.2	138.9
Gold quartz	112.4	115.7	121.6	134.6	142.7	154.5
Iron	110.4	112.1	112.2	121.0	129.0	133.2
Other metal	104.1	106.6	110.3	118.4	125.6	134.1
Manufacturing	106.0	109.7	115.0	121.6	130.5	140.6
Non-durable	106.7	110.5	115.5	121.9	131.0	141.4
Petroleum refineries	106.8	109.8	112.6	123.1	131.4	139.3
Durable	105.1	108.9	114.4	121.2	130.0	139.7
Primary metal industries	105.9	109.3	114.8	116.5	123.1	128.5
Metal fabricating industries	104.9	109.3	115.7	125.0	131.2	140.4
Machinery industries	107.4	109.5	114.9	122.7	131.0	140.5
Transportation equipment industries	106.0	109.6	115.4	122.5	131.7	142.1
Electrical products industries	99.2	102.7	105.9	112.3	123.4	133.8
Construction	109.1	113.9	119.8	129.8	142.0	154.9
Transportation, communication and other utilities	106.0	109.8	114.3	122.3	132.8	143.4
Trade	107.9	111.0	116.9	123.9	132.5	144.5
Service	106.6	111.7	118.4	125.5	133.9	141.8
Local government (Municipal government only)	107.4	111.5	118.1	124.6	136.9	146.7
General Index – All Industries	107.0	110.9	116.5	124.0	133.4	143.8

* Average wage rate = the weighted average of straight-time rates paid on a time basis in an occupation.

TABLE 40

Canada, Average Weekly Wages and Hours Worked by Hourly-Rated Employees in Mining, Manufacturing, and Construction Industries, 1962-68

	1962	1963	1964	1965	1966	1967	1968P
Mining							
Average hours per week	41.7	42.0	42.2	42.5	42.3	41.9	41.8
Average weekly wage	90.98	93.87	97.43	103.30	110.29	119.09	128.28
Metals							
Average hours per week	41.5	41.5	41.7	41.9	41.6	41.3	41.2
Average weekly wage	93.92	96.22	99.48	105.76	112.99	122.79	131.55
Fuels							
Average hours per week	40.6	42.5	42.1	41.3	42.3	42.5	41.9
Average weekly wage	80.77	85.10	86.98	89.07	95.68	101.24	109.96
Nonmetals							
Average hours per week	41.1	41.1	41.7	42.7	42.1	42.3	42.4
Average weekly wage	86.02	89.66	94.42	99.49	104.00	112.35	121.24
Manufacturing							
Average hours per week	40.7	40.8	41.0	41.0	40.8	40.3	40.3
Average weekly wage	76.75	79.51	82.96	86.89	91.65	96.84	104.00
Construction							
Average hours per week	41.1	41.2	41.4	41.3	42.2	41.3	40.5
Average weekly wage	88.33	92.20	97.39	104.45	118.23	128.76	134.84

P Preliminary.

TABLE 41

Canada, Average Weekly Wages of Hourly-Rated Employees in the Mining Industry in Current and 1949 Dollars, 1962-68

	1962	1963	1964	1965	1966	1967	1968
Current Dollars							
All mining	90.98	93.87	97.43	103.30	110.29	119.09	128.28
Metals	93.92	96.22	99.48	105.76	112.99	122.79	131.55
Gold	75.76	77.38	80.27	84.71	91.12	95.72	101.26
Fuels	80.77	85.10	86.98	89.07	95.68	101.24	109.96
Coal	73.86	79.25	80.84	80.68	85.53	90.63	97.41
Nonmetallic	86.02	89.66	94.42	99.49	104.00	112.35	121.24
1949 Dollars							
All mining	69.61	70.58	71.96	74.48	76.64	80.20	86.09
Metals	71.86	72.35	73.47	76.25	78.52	82.72	88.28
Gold	57.96	58.18	59.28	61.07	63.32	64.24	69.76
Fuels	61.80	63.98	64.24	64.22	66.49	67.94	73.79
Coal	56.51	59.59	59.70	58.17	59.44	60.83	65.37
Nonmetallics	65.81	67.41	69.73	71.73	72.27	75.68	81.36

TABLE 42

Canada, Industrial Fatalities per Thousand Paid Workers in Main Industry Groups* 1955-68

	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968
Agriculture	0.83	1.03	0.95	1.00	0.92	0.62	0.61	0.56	0.48	0.72	0.48	0.54	0.30	0.26
Forestry	2.00	1.90	1.50	1.70	1.70	1.50	1.32	2.04	1.79	2.21	1.64	1.53	1.49	1.37
Fishing and Trapping	3.20	1.80	2.30	3.80	7.20	2.70	4.00	1.20	3.40	3.70	4.00	3.60	3.30	1.90
Mining**	1.60	2.10	1.50	2.20	2.00	1.92	1.73	1.89	2.33	1.87	1.24	1.13	1.62	1.03
Manufacturing	0.16	0.14	0.14	0.11	0.13	0.19	0.12	0.15	0.15	0.14	0.14	0.14	0.10	0.10
Construction	0.79	0.89	0.91	0.77	0.79	0.56	0.77	0.63	0.70	0.75	0.72	0.66	0.56	0.49
Transportation, Communication, and Other Utilities	0.56	0.56	0.50	0.40	0.44	0.37	0.36	0.38	0.42	0.43	0.49	0.41	0.37	0.26
Trade	0.07	0.08	0.09	0.05	0.06	0.06	0.06	0.07	0.07	0.07	0.07	0.05	0.06	0.04
Finance, Insurance and Real Estate	0.03	0.05	0.01	0.02	0.01	0.09	0.05	0.08	0.04	0.08	0.01	0.04	0.01	–
Service†	0.07	0.06	0.07	0.07	0.06	0.07	0.06	0.06	0.09	0.07	0.05	0.04	0.04	0.04
TOTAL	0.32	0.33	0.30	0.27	0.28	0.21	0.22	0.22	0.23	0.24	0.23	0.19	0.18	0.14

* Data for years 1961-1968 were revised according to 1960 standard industrial classification.

**Includes quarrying and oil-well drilling. Cement, lime and clay products manufacture are included under manufacture.

† Includes Public Administration.

TABLE 45

Canada, Ore Mined and Rock Quarried, Mining Industry, 1934-66

(millions of short tons)

	Metal Mines	Industrial Minerals Operations	Total
1934	18.8	8.8	27.6
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	178.5	341.3

TABLE 46

Canada, Exploration and Development Expenditures* in Metal and Nonmetal Mining, 1967 and 1968

($ million)

	1967	1968
Exploration		
Outside exploration	52.8	67.4
On property exploration	21.2	27.7
Total Exploration	74.0	95.1
Mine or on property development	**132.1**	**146.8**
Total Exploration and Development	206.1	241.9

*These expenditures on exploration and development are the results of a survey on mining exploration and development expenditures instituted by the Dominion Bureau of Statistics in 1967. All mining companies, both producers and non-producers, in the metallic and nonmetallic mining sectors were covered. Mining companies classified to the fuels area (coal, petroleum, gas) were not covered in this survey.

TABLE 47

Canada, Cost of Prospecting by Producing Metal Mines, by Provinces and by Types of Operations, 1965

($000)

	Placer Gold Operations	Gold Mines	Copper-Gold-Silver Mines	Silver-Cobalt Mines	Silver-Lead-Zinc Mines	Nickel-Copper Mines	Miscellaneous Metal Mines*	Total
Newfoundland	–	21	3	–	481	–	– –	505
Nova Scotia	–	29	–	–	–	–	–	29
New Brunswick	–	148	28	–	–	2	13	191
Quebec	–	636	621	7	53	369	259	1,945
Ontario	–	1,397	273	341	58	4,491	2,428	8,988
Manitoba	–	138	68	–	–	3,111	1	3,318
Saskatchewan	–	78	13	–	–	137	132	360
Alberta	–	160	–	–	9	–	–	169
British Columbia	39	498	241	–	142	441	273	1,634
Yukon	–	396	–	–	470	181	–	1,047
Northwest Territories	–	220	–	–	70	– –	9	299
Total Canada	39	3,721	1,247	348	1,283	8,732	3,115	18,485

*Includes iron, uranium, molybdenum mining, etc.

Note: The amounts shown are the expenditures incurred by producing metal mining companies, classified by their main type of metal mining activity. These expenditures, however, apply to prospecting conducted by such companies in all sectors of the mineral industry. If, for example a company whose chief activity is gold quartz mining, expands funds on prospecting for lead and zinc, such expenditures are included in the column headed "Gold Mines" in this table.

– Nil; – – less than $1,000.

TABLE 48

Canada, Cost of Prospecting by Producing Metal Mines, by Provinces and by Types of Operations, 1961-65

($000's)

	Placer Gold Operations	Gold Mines	Copper-Gold-Silver Mines	Silver-Cobalt Mines	Silver-Lead-Zinc Mines	Nickel-Copper Mines	Miscellaneous Metal Mines*	Total
1961	73	2,384	1,447	21	1,890	881	1,720	8,416
1962	88	2,388	1,587	25	1,743	5,506	2,156	13,493
1963	167	2,158	700	64	2,920	1,838	2,687	10,534
1964	58	3,039	433	80	1,646	4,848	1,973	12,077
1965	39	3,721	1,247	348	1,283	8,732	3,115	18,485

*Includes iron, uranium, molybdenum mining, etc.
See note bottom of Table 47.

TABLE 49

Canada, Diamond Drilling on Metal Deposits by Mining Companies with Own Equipment and by Drilling Contractors, 1954-66

(footage)

	Gold-Quartz Deposits	Copper-Gold-Silver and Nickel-Copper Deposits	Silver-Lead-Zinc Deposits	Other Metal Bearing Deposits*	Total Metal Deposits
1954	2,418,853	2,710,920	891,972	653,206	6,674,951
1955	2,354,572	2,873,826	1,121,578	1,763,820	8,113,796
1956	2,239,502	4,889,428	1,311,282	1,257,977	9,698,189
1957	2,317,170	3,603,971	1,062,020	942,794	7,925,955
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	2,960,263	3,363,019	1,148,886	1,176,768	8,648,936
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

*Includes iron, chromite, titanium, uranium, molybdenum deposits.
Note: Beginning in 1964 non-producing companies are not included.

TABLE 50

Canada, Exploration Diamond Drilling, Metal Deposits, 1954-66

(footage)

	By Mining Companies with Own Personnel and Equipment	By Diamond Drill Contractors	Total
1954	969,858	3,641,220	4,611,078
1955	1,522,696	5,072,263	6,594,959
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

Note: Beginning in 1964 non-producing companies are not included.

TABLE 51

Canada, Contract Diamond Drilling Operations, 1957-66

	Footage Drilled ft.	Income from Drilling $ millions	Average No. of Employees number	Total of Salaries & Wages $ millions
1957	6,296,128	21.2	2,951	10.8
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

TABLE 52

Canada, Contract Drilling for Oil and Gas, 1958-66

	Footage Drilled (feet)				Gross Income from Drilling	Average No. of Employees	Total Salaries & Wages
	Rotary	Cable	Diamond	Total	$ millions	Number	$ millions
1958	12,998,094	446,451	–	13,444,545	69.3	5,261	24.1
1959	13,020,214	317,719	7,567	13,345,500	63.8	4,734	21.4
1960	13,538,783	231,748	–	13,770,531	75.2	4,860	23.2
1961	12,616,950	170,098	–	12,787,048	68.6	4,144	21.7
1962	12,459,736	252,467	–	12,712,203	62.2	3,800	20.8
1963	14,783,110	361,979	–	15,145,089	75.9	4,179	22.9
1964	14,803,776	229,726	6,230	15,039,732	81.9	4,158	25.2
1965	15,997,276	340,345	–	16,337,621	100.2	4,648	31.7
1966	13,394,413	210,104	–	13,604,517	95.8	4,428	33.9

TABLE 53

Crude Minerals* Transported by Canadian Railways, 1967 and 1968

	1967 000 short tons	1968 000 short tons
Coal		
Anthracite	713	548
Bituminous	9,611	8,263
Iron ore	41,732	47,203
Aluminum ores and concentrates	2,924	2,815
Copper ores and concentrates	1,554	1,698
Copper-nickel ores and concentrates	4,909	5,416
Lead ores and concentrates	686	777
Zinc ores and concentrates	2,828	2,980
Ores and concentrates, other	777	683
Barite	48	54
Clay and bentonite	576	610
Sand	1,206	1,265
Sand and gravel	3,999	4,326
Stone, crushed and ground	5,475	5,078
Stone, fluxing and dolomite	337	243
Stone, rough	36	725
Stone, dressed	15	17
Petroleum, crude	316	367
Salt	1,358	1,336
Phosphate rock	1,900	1,780
Sulphur	2,256	2,521
Asbestos	1,173	1,216
Gypsum, crude	3,735	4,221
Products of mines, other	1,367	1,527
Total	89,531	95,669
Total all revenue freight moved by Canadian railways	209,453	215,417
Crude minerals as a percentage of total revenue freight moved by Canadian railways	42.7	44.4

*Domestic and imported.

TABLE 54

Crude Minerals* Transported by Canadian Railways, 1958-68

(millions of short tons)

	Total of Revenue Freight	Total of Crude Minerals	Crude Minerals as a % of Revenue Freight
1958	153.4	57.8	37.6
1959	166.0	69.2	41.7
1960	157.4	62.9	39.9
1961	153.1	59.6	38.9
1962	160.9	66.5	41.3
1963	170.4	69.3	40.7
1964	198.4	82.3	41.5
1965	205.2	89.2	43.5
1966	214.4	88.9	41.5
1967	209.5	89.5	42.7
1968	215.4	95.6	44.4

*Domestic and imported.

TABLE 55

Fabricated Mineral Products* Transported by Canadian Railways, 1967 and 1968

	1967 000's short tons	1968 000's short tons
Aluminum: bar, ingot, pig, shot	635	725
Aluminum metal, other	117	122
Copper: ingot and pig	575	794
Copper, brass and bronze, other	256	121
Lead and zinc: bar, ingot, pig	597	648
Lead and zinc, other	6	8
Alloys for manufacture of steel	133	145
Metals and alloys, other	93	103
Iron, pig	225	216
Iron and steel: billet, bloom, ingot	503	688
Iron and steel: bar, rod, slab	533	721
Iron and steel, other	53	66
Matte	321	331
Furnace slag	218	303
Cement, natural and portland	1,712	1,904
Cement, other	70	58
Brick, common	74	73
Brick, other and building tile	125	101
Refractories	300	278
Artificial stone	65	71
Lime	571	633
Plaster: stucco and wall	68	66
Sewer pipe and drain tile	9	7
Broken brick and crockery	13	10
Gasoline	2,988	2,865
Fuel oil and petroleum oil	4,526	4,684
Lubricating oils and greases	389	408
Petroleum products, refined	2,226	2,455
Coke	1,796	1,796
Asphalt	333	353
Total	19,530	20,753
Total all revenue freight	209,453	215,417
Fabricated minerals as a per cent of total freight	9.3	9.6

*Domestic and imported.

TABLE 56

Crude and Fabricated Minerals* Transported Through Canadian Canals**, 1967

	1967 000's short tons
Crude Minerals	
Alumina and bauxite ores	186
Copper ore, concentrates, matte, precipitate	2
Iron ore, crude, concentrated, calcined	32,797
Manganese ore	394
Nickel-copper ore, matte, concentrates	4
Ores, concentrates, precipitates, n.e.s.	48
Iron and steel scrap	930
Nonferrous and precious metal scrap	70
Slag, dross and byproducts	25
Coal, bituminous, subbituminous and lignite	9,830
Coal, n.e.s.	1
Crude petroleum and natural gasoline	239
Natural gas and other crude bituminous substances	8
Asbestos, unmanufactured	6
Bentonite	230
China clay	60
Dolomite	1,134
Clay and other crude refractory materials, n.e.s.	101
Sand and gravel	216
Limestone	10
Crushed stone, including stone refuse, excluding limestone	1
Stone, crude, n.e.s.	60
Fluorspar	320
Gypsum	59
Phosphate rock	133
Salt	1,320
Sulphur in ores, crude and refined	51
Crude nonmetallic minerals, n.e.s.	52
Total crude minerals	48,287
Fabricated	
Gasoline	828
Fuel oil	3,586
Lubricating oils and greases	346
Coke of petroleum and coal	490
Asphalt and road oils	45
Coal tar and coal pitch	113
Petroleum and coal products, n.e.s.	291
Ferroalloys	140
Pig iron	476
Primary iron and steel, n.e.s.	59
Castings and forgings (except pipes and fittings)	42
Bars and rods, steel	670
Plate, sheet, strip, steel	4,422
Structural shapes and sheet piling	1,218
Rails and railway track material	4
Pipes and tubes, iron and steel	96
Wire and wire rope	189
Aluminum, including alloys	46
Copper and alloys	20
Lead and alloys	28
Nickel and alloys	16
Zinc and alloys	61
Nonferrous metals, n.e.s.	13
Metal fabricated basic products, n.e.s.	212
Building brick, clay	†
Bricks, tiles, n.e.s.	22
Glass basic products	118
Asbestos and asbestos cement basic products	1
Cement	244
Cement basic products	1
Nonmetallic mineral basic products, n.e.s.	50
Total fabricated minerals	13,847
Total, crude and fabricated minerals	62,134
Total all freight transported	98,774
Per cent crude and fabricated minerals of total freight	62.9

*Domestic and imported. **Canals and inland waterways include: St. Lawrence, Welland, Sault Ste. Marie, St. Peter's, Canso, Richelieu River, Ottawa River, Rideau, Murray, Trent and St. Andrews.

n.e.s.: Not elsewhere spedified.

†Less than 1 thousand tons.

TABLE 57

Quantities* of Petroleum and Petroleum Products and
Gas (Manufactured and Natural) Transported by Pipeline in Canada,
1954-68

	Petroleum and Petroleum Products			Gas		
	Domestic Sales	Export Sales	Total	Domestic Sale	Export Sales	Total
	millions of bbl.	millions of bbl.	millions of bbl.	000 Mcf	000 Mcf	000 Mcf
1954	156.8	15.7	172.5	102,500[e]	6,984	109,484
1955	178.8	45.5	224.3	136,738	11,356	148,094
1956	215.6	59.3	274.9	163,764	10,828	174,592
1957	258.2	32.6	290.8	184,738	15,731	200,469
1958	239.3	35.5	274.8	211,751	86,973	298,726
1959	273.5	35.0	308.5	283,808	84,764	368,572
1960	274.2	41.8	316.0	326,212	91,046	417,258
1961	286.1	67.3	353.4	379,044	168,180	547,224
1962	300.9	86.6	387.5	421,631	319,566	741,197
1963	339.8	91.3	431.1	452,943	340,953	793,896
1964	355.7	104.2	459.9	505,145	404,143	909,288
1965	373.3	110.3	483.6	573,016	403,909	976,925
1966	406.5	129.7	536.2	635,515	426,224	1,061,739
1967	419.2	154.5	573.7	699,674	505,165	1,204,839
1968	455.0	172.8	627.8	765,786	607,355	1,373,141

*Domestic and imported:
[e]Estimated.

TABLE 58

Canada – Taxes* Paid to Federal, Provincial and Municipal Governments by Important Divisions of the Mining Industry, 1965 and 1966

($000)

	1965				1966			
	Federal Income Tax	Provincial Tax	Municipal Tax	Total	Federal Income Tax	Provincial Tax	Municipal Tax	Total
Auriferous-quartz mining	1,769	1,767	904	4,440	2,633	1,577	961	5,171
Copper-gold-silver mining, smelting and refining	21,562	10,686	2,680	34,928	18,866	12,690	2,775	34,331
Silver-lead-zinc mining, smelting and refining	15,870	9,926	2,095	27,891	11,078	9,442	2,383	22,903
Nickel-copper, mining, smelting and refining	49,870	25,354	2,473	77,697	43,976	23,989	2,780	70,745
Iron mining	2,121	6,144	3,292	11,557	1,913	8,761	4,307	14,981
Miscellaneous metal mining	–	1,248	523	1,771	22	1,346	585	1,953
Asbestos mining	13,731	6,591	2,149	22,471	14,479	9,798	2,069	26,346
Feldspar, quartz, nepheline syenite mining	17	52	29	98	26	85	26	137
Gypsum mining	512	330	270	1,112	897	306	284	1,487
Peat mining	66	36	92	194	23	64	75	162
Salt mining	–	293	286	579	–	559	303	862
Talc and soapstone mining	2	11	6	19	2	15	7	24
Stone quarries	2,067	785	540	3,392	1,378	666	372	2,417
Sand and gravel pits	626	431	254	1,311	499	636	296	1,432
Miscellaneous non-metal mining	2,635	1,694	560	4,889	2,644	2,547	736	5,927
Total of sectors covered	110,848	65,348	16,153	192,349	98,436	72,481	17,959	188,878

*The above amounts refer only to payments actually made within the calendar year specified. These tax payments do not necessarily reflect the tax assessments of a calendar year. Included are taxes on non-operating revenue.

TABLE 59

Canada – Taxes* Paid by Six Important Divisions of the Mineral Industry, 1960-66
($ millions)

	1960	1961	1962	1963	1964	1965	1966
Auriferous quartz mining	6.5	7.0	6.1	6.5	5.2	4.4	5.2
Copper-gold-silver mining	19.7	20.1	15.2	20.3	26.0	34.9	34.3
Silver-lead-zinc mining, smelting and refining	15.3	15.7	17.7	20.5	26.5	27.9	22.9
Nickel-copper-mining, smelting and refining	41.0	38.2	51.6	35.9	47.8	77.7	70.7
Iron mining	6.6	5.6	7.5	11.0	6.1	11.6	15.0
Asbestos mining	14.2	16.8	18.4	18.6	20.3	22.5	26.3
Total	103.3	103.4	116.5	112.8	131.9	179.0	174.4

* See footnote Table 58.

TABLE 60

Canada, Capital and Repair Expenditure in the Mineral Industry 1967, 1968, 1969

($ million)

	1967*			1968p			1969f		
	Capital	Repair	Total	Capital	Repair	Total	Capital	Repair	Total
Mining industry									
Metal mines									
Gold	11.2	9.6	20.8	8.4	7.5	15.9	7.8	6.8	14.6
Silver, lead, zinc	48.2	9.9	58.1	66.8	10.7	77.5	52.4	12.3	64.7
Iron mines	104.9	65.9	170.8	45.9	91.3	137.2	37.3	81.7	119.0
Other metal mines	205.1	64.6	269.7	209.8	80.9	290.7	199.2	82.5	281.7
Total metal mines	369.4	150.0	519.4	330.9	190.4	521.3	296.7	183.3	480.0
Nonmetal mines[1]									
Quarries and sand pits	9.3	11.7	21.0	7.2	11.2	18.4	7.8	11.6	19.4
Other nonmetal mines[1]	197.2	49.8	247.0	231.5	38.5	270.0	172.8	43.3	216.1
Total nonmetal mines	206.5	61.5	268.0	238.7	49.7	288.4	180.6	54.9	235.5
Mineral Fuels									
Petroleum and gas	474.8	48.9	523.7	470.2	69.1	539.3	605.9	74.1	680.0
Total mining industry	1,050.7	260.4	1,311.1	1,039.8	309.2	1,349.0	1,083.2	312.3	1,395.5
Mineral manufacturing									
Primary metal industries									
Iron and steel mills	122.9	139.9	262.8	85.8	152.2	238.0	149.7	155.5	305.2
Steel pipe and tube mills	8.6	7.9	16.5	9.9	9.5	19.4	10.5	9.6	20.1
Iron foundries	9.0	9.6	18.6	6.1	8.6	14.7	10.2	8.9	19.1
Smelting and refining	123.0	109.0	232.0	126.4	116.3	242.7	187.9	112.5	300.4
Aluminum rolling, casting and extruding[2]	4.5	7.2	11.7	..	..	..	16.4	5.4	21.8
Copper and alloy rolling, casting and extruding	10.1	4.4	14.5	8.1	4.6	12.7	4.8	5.7	10.5
Other primary metal industries	6.7	5.0	11.7	16.9	9.1	26.0	2.8	2.9	5.7
Total primary metal industries	284.8	283.0	567.8	253.2	300.3	553.5	382.3	300.5	682.8

TABLE 60 (Contd.)

	1967*			1968P			1969f		
	Capital	Repair	Total	Capital	Repair	Total	Capital	Repair	Total
Nonmetallic mineral products									
Cement	28.3	12.6	40.9	17.5	11.7	29.2	13.2	12.1	25.3
Lime	2.0	1.2	3.2	.3	1.2	1.5	.9	1.0	1.9
Gypsum products	.8	.7	1.5	1.4	.7	2.1	3.4	.8	4.2
Concrete products and ready mix	30.3	31.1	61.4	18.3	31.4	50.1	25.1	32.1	57.2
Clay products	3.0	4.8	7.8	3.4	4.8	8.2	8.9	4.3	13.2
Refractories	1.4	1.3	2.7	3.4	1.4	4.8	2.8	1.5	4.3
Stone products	.3	.2	.5	.2	.2	.4	.3	.2	.5
Asbestos[3]	2.4	2.1	4.5	3.0	2.4	5.4	. .	. .	. .
Glass and glass products	42.5	12.2	54.7	24.9	14.2	39.1	37.3	13.9	51.2
Abrasives	4.3	4.3	8.6	2.4	3.8	6.2	4.1	4.2	8.3
Other nonmetallic mineral products	4.5	2.7	7.2	2.5	3.6	6.1	4.4	6.3	10.7
Total nonmetallic mineral products	119.8	73.2	193.0	77.7	75.4	153.1	100.4	76.4	176.8
Petroleum and coal products	100.2	46.2	146.4	127.5	52.6	180.1	179.5	54.7	234.2
Total mineral manufacturing industries	504.8	402.4	907.2	458.4	428.3	886.7	662.2	431.6	1,093.8

1 Includes coal mines, asbestos, gypsum, salt, miscellaneous nonmetal mines and quarrying.
2 Detail not available for 1968, included under "Other primary metal industries".
3 Detail not available for 1969, included under "Other nonmetallic mineral products".
* Actual expenditure; P Preliminary; f Forecast; . . Not available.

TABLE 61

Canada, Capital and Repair Expenditure in the Mining[1] Industry 1960 - 69
($ millions)

	1960	1961	1962	1963	1964	1965	1966	1967	1968P	1969f
Metal mines										
Capital – Construction	88.8	107.6	137.8	118.3	146.8	121.4	209.8	238.1	220.7	202.0
Machinery	46.6	42.5	71.2	71.6	92.7	79.2	138.6	131.3	110.2	94.7
Total	135.4	150.1	209.0	189.9	239.5	200.6	348.4	369.4	330.9	296.7
Repair – Construction	14.6	12.8	14.0	15.8	17.8	21.9	25.2	33.4	35.6	34.4
Machinery	47.8	55.7	64.5	76.3	84.5	100.5	115.9	116.6	154.8	148.9
Total	62.4	68.5	78.5	92.1	102.3	122.4	141.1	150.0	190.4	183.3
Total Capital and Repair	197.8	218.6	287.5	282.0	341.8	323.0	489.5	519.4	521.3	480.0
Nonmetal mines[2]										
Capital – Construction	12.4	15.9	24.7	18.7	36.7	58.1	106.7	121.1	102.1	74.0
Machinery	18.7	20.8	35.5	40.8	44.9	34.8	68.8	85.4	136.6	106.6
Total	31.1	36.7	60.2	59.5	81.6	92.9	175.5	206.5	238.7	180.6
Repair – Construction	2.7	3.1	3.3	3.6	3.2	3.7	3.5	4.5	3.2	4.0
Machinery	26.9	28.6	27.6	31.5	37.9	47.2	49.5	57.0	46.5	50.9
Total	29.6	31.6	30.9	35.1	41.1	50.9	53.0	61.5	49.7	54.9
Total Capital and Repair	60.7	68.4	91.1	94.6	122.7	143.8	228.5	268.0	288.4	235.5
Mineral fuels										
Capital – Construction	202.2	238.4	176.8	234.3	270.6	419.2	450.0	403.0	418.9	509.3
Machinery	31.5	23.6	33.7	37.9	40.4	22.1	55.7	71.8	51.3	96.6
Total	233.7	262.0	210.5	272.2	311.0	441.3	505.7	474.8	470.2	605.9
Repair – Construction	9.4	10.2	13.6	15.7	23.6	25.4	28.6	34.2	44.5	48.1
Machinery	11.0	11.4	12.3	13.9	10.8	24.0	21.3	14.7	24.6	26.0
Total	20.4	21.6	25.9	29.6	34.4	49.4	49.9	48.9	69.1	74.1
Total Capital and Repair	254.1	283.6	236.4	301.8	345.4	490.7	555.6	523.7	539.3	680.0

TABLE 61 (cont'd.)

Total mining										
Capital – Construction	303.4	361.9	339.3	371.3	454.1	598.7	766.5	762.2	741.7	785.3
Machinery	96.8	86.9	140.4	150.3	178.0	136.1	263.1	288.5	298.1	297.9
Total	400.2	448.8	479.7	521.6	632.1	734.8	1,029.6	1,050.7	1,039.8	1,083.2
Repair – Construction	26.7	26.1	30.9	35.1	44.6	51.0	57.3	72.1	83.3	86.5
Machinery	85.7	95.7	104.4	121.7	133.2	171.7	186.7	188.3	225.9	225.8
Total	112.4	121.8	135.3	156.8	177.8	222.7	244.0	260.4	309.2	312.3
Total capital and repair	512.6	570.6	615.0	678.4	809.9	957.5	1,273.6	1,311.1	1,349.0	1,395.5

[1] Does not include cement, lime and clay products (domestic clays) manufacturing. [2] Includes coal mines, asbestos, gypsum; salt, miscellaneous nonmetals and quarrying.

[p] Preliminary; [f] Forecast.

TABLE 62

Canada, Capital and Repair Expenditure in the Mineral Manufacturing Industries 1960 - 69
($ millions)

	1960	1961	1962	1963	1964	1965	1966	1967	1968P	1969f
Primary metal industries										
Capital – Construction	51.3	32.9	58.4	44.4	58.4	61.6	85.2	82.0	76.7	95.9
Machinery	142.9	93.7	159.1	136.8	214.4	202.9	300.7	202.8	176.5	286.4
Total	194.2	126.6	217.5	181.2	272.8	264.5	385.9	284.8	253.2	382.3
Repair – Construction	20.0	19.0	18.5	16.6	18.0	18.5	21.8	24.9	25.5	26.3
Machinery	145.0	134.9	151.9	166.1	194.4	215.0	253.4	258.1	274.8	274.2
Total	165.0	153.9	170.4	182.7	212.4	233.5	275.2	283.0	300.3	300.5
Total Capital and Repair	359.2	280.5	387.9	363.9	485.2	498.0	661.1	567.8	553.5	682.8
Nonmetallic mineral products[1]										
Capital – Construction	15.7	11.8	13.7	13.8	20.1	30.0	50.9	39.5	10.5	24.9
Machinery	33.3	32.8	38.4	38.9	61.9	78.3	108.6	80.3	67.2	75.5
Total	49.0	44.6	52.1	52.7	82.0	108.3	159.5	119.8	77.7	100.4
Repair – Construction	4.2	4.3	5.2	5.5	5.4	6.4	7.2	9.3	6.6	6.5
Machinery	38.3	41.9	51.3	52.8	58.3	66.1	72.1	63.9	68.8	69.9
Total	42.5	46.2	56.5	58.3	63.7	72.5	79.3	73.2	75.4	76.4
Total Capital and Repair	91.5	90.8	108.6	111.0	145.7	180.8	238.8	193.0	153.1	176.8
Petroleum and Coal Products										
Capital – Construction	52.0	27.7	56.7	38.0	20.4	30.3	55.5	78.8	97.5	146.7
Machinery	7.8	4.0	8.9	8.6	4.3	10.3	9.6	21.4	30.0	32.8
Total	59.8	31.7	65.6	46.6	24.7	40.6	65.1	100.2	127.5	179.5
Repair – Construction	26.0	26.1	28.1	30.0	32.3	29.5	32.6	36.0	42.8	43.3
Machinery	4.2	4.4	4.9	5.2	5.9	7.0	9.1	10.2	9.8	11.4
Total	30.2	30.5	33.0	35.2	38.2	36.5	41.7	46.2	52.6	54.7
Total Capital and Repair	90.0	62.2	98.6	81.8	62.9	77.1	106.8	146.4	180.1	234.2
Total mineral manufacturing industries										
Capital – Construction	119.0	72.4	128.8	96.2	98.9	121.9	191.6	200.3	184.7	267.5
Machinery	184.0	130.5	206.4	184.3	280.6	291.5	418.9	304.5	273.7	394.7
Total	303.0	202.9	335.2	280.5	379.5	413.4	610.5	504.8	458.4	662.2
Repair – Construction	50.2	49.4	51.8	52.1	55.7	54.4	61.6	70.2	74.9	76.1
Machinery	187.5	181.2	208.1	224.1	258.6	288.1	334.6	332.2	353.4	355.5
Total	237.7	230.6	259.9	276.2	314.3	342.5	396.2	402.4	428.3	431.6
Total capital and repair	540.7	433.5	595.1	556.7	693.8	755.9	1,006.7	907.2	886.7	1,093.8

[1] Includes cement, lime and clay products manufacturing.

P Preliminary; f Forecast.

TABLE 63

Canada, Capital Investment in Petroleum and Natural Gas Industries[1] 1961-69
($ millions)

	Production[2] and exploration and development drilling	Oil Pipelines	Gas Transmission Pipelines	Gas Processing	Petroleum Refining	Marketing		Total Capital Investment	
						Oil[3]	Gas[4]	Petroleum and Natural Gas Industries	All Industries
1961	272.0	49.3	115.5	76.5	31.2	56.0	59.3	659.8	8,109.0
1962	269.0	20.8	51.4	22.0	64.8	47.7	69.3	545.0	8,738.0
1963	282.1	26.0	81.9	53.6	44.2	53.0	84.1	624.9	9,312.0
1964	336.7	29.0	135.1	40.6	23.9	48.3	68.3	681.9	10,827.0
1965	381.0	52.5	59.6	41.5	39.8	55.2	72.5	702.1	12,795.0
1966	453.5	81.6	72.3	50.1	64.8	64.0	92.3	878.6	14,897.0
1967	385.1	97.3	104.9	89.7	99.6	86.8	76.4	939.8	15,174.0
1968	375.5	67.1	164.0	94.7	127.3	84.0	115.9	1,028.5	15,678.0
1969[f]	445.3	56.9	140.6	127.3	179.3	107.8	107.1	1,164.3	17,356.0

[1] The petroleum and natural gas industries in this table include all companies engaged, in whole or in part, in oil and gas industry activities.
[2] Includes capital expenditure in production, tar sands and contract drilling. [3] Chiefly outlets reported by major companies. [4] Gas distribution pipelines.
[f] Forecast.

TABLE 64

Foreign Capital Invested in the Canadian Mineral Industry,
End of Year, 1945, and 1959-65
($ millions)

	1945	1959	1960	1961	1962	1963	1964	1965
Owned by all non-residents								
Mining and nonferrous smelting	356	1,783	1,977	2,094	2,297	2,347	2,473	2,555
Petroleum and gas	160	3,455	3,727	4,029	4,384	4,703	4,799	5,192
Owned by United States residents								
Mining and nonferrous smelting	277	1,513	1,701	1,821	1,998	2,054	2,115	2,199
Petroleum and gas	152	3,108	3,184	3,444	3,662	3,945	3,964	4,170
Owned by United Kingdom residents								
Mining and nonferrous smelting	60	160	152	148	184	161	211	199
Petroleum and gas	7	162	270	296	355	380	449	524
Owned in all other countries								
Mining and nonferrous smelting	19	110	124	125	115	132	147	157
Petroleum and gas	1	185	273	289	367	378	386	498

TABLE 65

Canada, Corporations in the Mining Industry Reporting Under the Corporations and Labour Returns Act, 1964

	Corporations	Assets	Equity	Sales	Profits
	number	$ million	$ million	$ million	$ million
Metal mining					
Gold mines	83	545.6	490.1	120.7	50.0
Copper-gold-silver mines	95	677.1	519.6	245.3	94.9
Nickel-copper mines	12	194.4	181.2	90.7	36.0
Silver-lead-zinc mines	37	245.8	112.5	110.2	34.0
Uranium mines	9	318.2	201.0	127.9	16.8
Iron mines	43	1,163.7	405.3	407.0	80.5
Other metal mines	31	65.5	47.0	13.7	0.6
Total metal mines	310	3,210.3	1,956.7	1,115.5	312.8
Degree of non-resident ownership					
over 50%	72	1,505.5	566.0	570.6	110.1
Per cent of total	23.2	46.9	28.9	51.2	35.2
under 50%	238	1,704.8	1,390.7	544.9	202.7
Per cent of total	76.8	53.1	71.1	48.8	64.8
Total	310	3,210.3	1,956.7	1,115.5	312.8
Nonmetal mines					
Asbestos mines	15	283.8	230.3	181.4	50.3
Gypsum, salt and other nonmetal mines	43	262.1	145.1	102.0	20.4
Quarries and sand pits	102	83.1	35.5	65.9	5.7
Services incidental to mining	202	369.9	232.5	166.1	8.1
Total nonmetal mines	362	998.9	643.4	515.4	84.5
Degree of non-resident ownership					
over 50%	103	592.3	363.8	289.9	61.0
Per cent of total	28.5	59.3	56.5	56.2	72.2
under 50%	259	406.6	279.6	225.5	23.5
Per cent of total	71.5	40.7	43.5	43.8	27.8
Total	362	998.9	643.4	515.4	84.5
Mineral fuels					
Coal mines	28	64.1	35.0	32.6	2.7
Petroleum and natural gas	246	3,257.8	2,219.8	929.3	165.6
Total mineral fuels	274	3,321.9	2,254.8	961.9	168.3
Degree of non-resident ownership					
over 50%	144	2,781.1	1,899.5	853.9	141.9
Per cent of total	52.6	83.7	84.2	88.8	84.3
under 50%	130	540.8	355.3	108.0	26.4
Per cent of total	47.4	16.3	15.8	11.2	15.7
Total	274	3,321.9	2,254.8	961.9	168.3
Total mining industry	946	7,531.1	4,854.9	2,592.8	565.6
Degree of non-resident ownership					
over 50%	319	4,878.9	2,829.3	1,714.4	313.0
Per cent of total	33.7	64.8	58.3	66.1	55.3
under 50%	627	2,652.2	2,025.6	878.4	252.6
Per cent of total	66.3	35.2	41.7	33.9	44.7
Total	946	7,531.1	4,854.9	2,592.8	565.6

TABLE 66

Canada, Financial Statistics – Mining and Mineral Fabricating Industries, 1966
($ millions)

	Assets	Liabilities	Equity	Income	Expenses	Net Profit	Per Cent Net Profit of Assets
Mining Industry							
Metal mines							
Gold	560.5	43.1	517.4	154.0	116.9	37.2	6.6
Iron	1,399.6	864.7	535.0	515.8	460.5	55.2	3.9
Other metal mines	1,983.0	494.0	1,489.0	919.7	667.8	251.9	12.7
Total	3,943.1	1,401.8	2,541.4	1,589.5	1,245.2	344.3	8.7
Nonmetal mines and services							
Nonmetal mines	761.5	220.3	541.3	361.6	296.0	65.6	8.6
Quarries	139.5	92.4	46.9	130.7	125.4	5.3	3.8
Mining services	760.6	293.8	466.8	229.6	218.0	11.6	15.3
Total	1,661.6	606.5	1,055.0	721.9	639.4	82.5	5.0
Mineral fuels							
Coal mines	69.1	30.5	38.6	39.9	37.7	2.2	3.2
Oil and gas wells	4,058.4	1,452.8	2,605.6	1,069.8	895.9	173.9	4.3
Total	4,127.5	1,483.3	2,644.2	1,109.7	933.6	176.1	4.3
Total mining industry	9,732.2	3,491.6	6,240.6	3,421.1	2,818.2	602.9	6.2
Mineral Manufacturing							
Primary metals							
Iron and steel mills	2,145.8	949.5	1,196.3	1,546.8	1,437.8	109.0	5.1
Iron foundries	183.1	80.4	102.8	282.5	271.7	10.8	5.9
Smelting and refining	2,716.8	1,176.5	1,540.3	1,675.9	1,455.2	220.7	8.1
Total	5,045.7	2,206.4	2,839.4	3,505.2	3,164.7	340.5	6.7

TABLE 66 (cont'd.)

Nonmetallic mineral products							
Cement manufacturing	550.0	268.9	281.2	235.5	208.6	26.9	4.9
Concrete "	164.9	104.4	60.5	195.3	189.1	6.2	3.7
Ready-mix	217.2	133.7	83.5	318.1	308.5	9.6	4.4
Clay products	68.4	28.0	40.3	82.8	80.2	2.6	3.8
Glass and glass products	173.6	76.9	96.6	184.4	179.0	5.3	3.1
Other	208.0	60.2	147.8	234.3	215.2	19.1	9.2
Total	1,382.1	672.1	709.9	1,250.4	1,180.6	69.7	5.0
Petroleum and coal products							
Petroleum refineries	3,834.5	1,217.3	2,617.2	3,231.0	3,002.9	228.1	5.9
Other petroleum and coal products	25.7	10.8	14.9	23.0	21.7	1.3	5.1
Total	3,860.2	1,228.1	2,632.1	3,254.0	3,024.6	229.4	5.9
Total mineral manufacturing	10,288.0	4,106.6	6,181.4	8,009.6	7,369.9	639.6	6.2

Lightweight Aggregates

H.S. WILSON*

The lightweight aggregate industry recovered from the decrease in production sustained in 1967, and reached a new high of $7.84 million in 1968, an increase of 13.8 per cent over the 1967 value.

The expanded clay and shale aggregates showed the greatest increase, amounting to 20.5 per cent in volume and 21.4 per cent in value. Of the nine plants in production in 1968, five had increases in production, three had decreases and one maintained constant production from the previous year. The plant built by Avon Aggregates Ltd. at Minto, N.B., was not in full operation in 1968, but should be producing in 1969.

Construction of a plant was begun by Enercon Limited, at Mississauga, Ont. in 1968 to produce a lightweight aggregate by the sintering of fly ash. The plant, which will produce pozzolan, an iron-oxide concentrate and carbon particles should be in production in 1969. The raw material will be obtained from a steam-generating power plant west of Toronto, Ont.

Production of exfoliated vermiculite increased 13.8 per cent in volume and 19.7 per cent in value over the 1967 figures. Three of the five companies had increases and two had decreases in production. Western Insulation Products Ltd. Edmonton, Alta., which in previous years had produced only expanded perlite, began production of exfoliated vermiculite as well, in 1968. The exfoliating plant, operated by F. Hyde & Company, Limited, in Toronto, was shut down in 1968.

Production of expanded perlite in 1968 was 3.0 per cent greater in volume and 11.1 per cent greater in value than in 1967. Of the nine Canadian producers, one more than in 1967, four had increased production and four had decreased production. One of the latter plants produced less than one tenth of its 1967 production. The new producer is Holmes Insulations Limited, Sarnia, Ontario. In recent years, expanded perlite has been gaining importance as cryogenic insulation for low temperature liquid-gas storage. In 1967 and 1968, Silbrico Corporation, Hodgkins, Ill., U.S.A., has been expanding perlite in Canada, at installation sites, using a portable expander. Some of the Canadian producers are obtaining portable equipment to produce this type of insulation.

Production of expanded slag decreased by 2.3 per cent in volume and 3.3 per cent in value. In 1968, National Slag Limited, Hamilton, Ont. developed a process which gives a pelletized aggregate. All other processes produce angular particles, whereas this new process gives particles essentially of spherical shape.

The quantity of pumice used as lightweight aggregate in 1968 was 52.8 per cent lower in value than in 1967.

Table 1 shows the volume and value of each of the lightweight aggregates produced in Canada in both 1967 and 1968; only the value of pumice imported into Canada in both years is given. The accompanying graph shows the production of the four principal lightweight aggregates for the years 1954 to 1968.

The total value of construction in Canada increased 5.6 per cent to $12.2 billion in 1968 from the 1967 value of $11.5 billion. However, on a constant 1957 dollar basis, construction actually decreased 0.4 per cent due to the continuing increases in costs of labour, materials and the value of land. Table 2 shows the year-to-year changes in construction from 1957 to 1968 on both a current dollar basis and a constant 1957 dollar basis. Table 3 shows the percentage changes of the various types of construction from 1966 to 1967 and from 1967 to 1968. It also shows the totals represented by each type for 1966, 1967, and 1968. All figures are on a current dollar basis.

* Mineral Processing Division, Mines Branch.

TABLE 1

Production of Lightweight Aggregates 1967-68

	1967		1968	
	Cubic Yards	$	Cubic Yards	$
From domestic raw materials				
Expanded clay and shale	451,285	2,527,575	543,603	3,069,260
Expanded slag	318,057	833,224	310,797	806,010
From imported raw materials				
Exfoliated vermiculite	286,593	2,551,796	332,319	3,056,126
Expanded perlite	87,000	760,000	89,600	844,000
Pumice		138,500		66,000
Total		6,811,095		7,841,396

Source: Statistics supplied to Mineral Processing Division by producers.

TABLE 2

Annual Value of Construction

Year	Total Value ($ xmillions)	Per Cent Change from Previous Year: Current Dollar Value	Per Cent Change from Previous Year: Constant (1957) Dollar Value
1957	7,023	8.8	5.1
1958	7,092	1.0	1.0
1959	7,077	−0.2	−3.5
1960	6,886	−2.7	−4.7
1961	6,973	1.3	2.1
1962	7,296	4.6	2.0
1963	7,716	5.8	2.1
1964	8,653	11.9	7.4
1965	9,868	14.3	7.1
1966	11,237	13.9	7.5
1967	11,594	3.2	−1.2
1968[p]	12,242	5.6	−0.4

Source: Dominion Bureau of Statistics.
[p]Preliminary.

RAW MATERIAL

The common clays and shales are the most widespread of the raw materials used for the production of lightweight aggregates. All plants obtain such materials locally. All use the rotary-kiln method of production.

Vermiculite is micaceous in appearance, but differs from mica in that it exfoliates or expands in one direction up to 15 times when heated to form a cellular material of low density and high insulating value. The raw vermiculite, sized and concentrated, is imported principally from the United States and in lesser quantities from South Africa.

Perlite is a volcanic rock that expands or 'pops' when heated, to form a white, cellular material of low density and good insulating properties. All the raw material is imported size from Colorado, New Mexico, and Utah.

Expanded slag is a processed byproduct of the production of pig iron in blast furnaces. Introduction of water into the molten slag causes it to expand.

Pumice is a vesicular material of volcanic origin that is used in its natural state as a lightweight aggregate. It is imported into Canada from the western United States and Greece.

Table 4 lists the lightweight aggregate-producing plants in operation in 1968.

CONSUMPTION

EXPANDED CLAY AND SHALE

Concrete block accounted for 74 per cent of production in 1968, compared with 79 per cent in 1967, and 76 per cent in 1966. Precast concrete shapes and cast-in-place structural concrete consumed 2 and 22 per cent respectively in 1968, compared with 3 and 17 per cent in 1967, and 2 and 19 per cent in 1966. Minor uses, such as aggregates in refractory products, soil conditioning, etc., accounted for 2 per cent of production in 1968, compared with 3 per cent in 1967 and 1966.

EXFOLIATED VERMICULITE

Loose insulation consumed 75 per cent of production in 1968, 78 per cent in 1967, and 72 per cent in 1966. Aggregate in plaster accounted for 11 per cent in 1968, compared with 9 per cent in 1967 and 14 per cent in 1966. Insulating concrete utilized 8 per cent in 1968, 7 per cent in 1967 and 11 per cent in 1966. Six per cent was used for such purposes as fireproofing, underground pipe insulation, barbecue base, texture spray in agriculture, etc., in 1968. Such minor uses consumed 6 per cent of production in 1966.

EXPANDED SLAG

Concrete block consumed 99 per cent of production in 1968, one per cent more than in the five previous years. One per cent was used in structural concrete, as insulation, fill and on running tracks.

EXPANDED PERLITE

Forty-two per cent was used as aggregate in plaster in 1968, compared with 63 per cent in 1967 and 71 per cent in 1966. Twenty per cent was produced for cryogenic insulation in 1968, up from 11 per cent in 1967. This product was supplied almost entirely by an American producer, operating in Canada. Industrial fillers consumed 10 per cent of production, 2 per cent less than in 1967. Eleven per cent of production in 1968 was as aggregate for insulating concrete, compared with 6 per cent in 1967. Insulation accounted for 5 per cent of production, and agriculture and other minor applications accounted for 12 per cent.

PUMICE

As in previous years, all the pumice imported as lightweight aggregate was used in concrete block.

TABLE 3

Construction in Canada 1966-68

Type of Construction	Percentage Change		Percentage of Total Value		
	1966-67	1967-68	1966	1967	1968p
Engineering	+ 4.2	+ 4.0	40.7	41.1	40.5
Residential	+ 7.8	+16.6	25.3	26.4	29.2
Commercial	– 2.3	– 5.3	11.1	10.5	9.4
Institutional	+ 7.5	+11.0	10.4	10.9	11.4
Industrial	–13.0	–16.0	8.9	7.5	6.0
Other building	+ 3.8	+ 3.4	3.6	3.6	3.5
Total construction	+ 3.2	+ 5.6	100.0	100.0	100.0

Source: Dominion Bureau of Statistics.
pPreliminary.

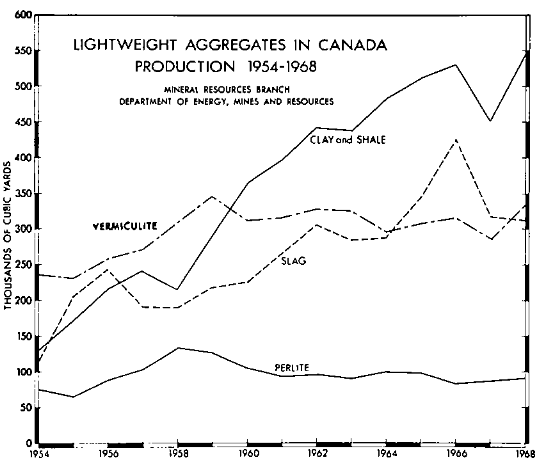
TABLE 4

Lightweight Aggregate Plants in Canada

Company	Location
Producing Plants	
Expanded clay	
Cindercrete Products Limited	Regina, Sask.
Consolidated Block and Pipe Ltd.	Regina, Sask.
Echo-Lite Aggregate Ltd.	St. Boniface, Man.
Edmonton Concrete Block Co. Ltd.	Edmonton, Alta.
Kildonan Concrete Products Ltd.	St. Boniface, Man.
Expanded shale	
British Columbia Lightweight Aggregates Ltd.	Saturna Island, B.C.
Cell-Rock Inc.	Lafleche, Que.
Consolidated Concrete Limited	Calgary, Alta.
Domtar Construction Materials Ltd.	Cooksville, Ont.

TABLE 4 (Cont'd)

Company	Location
Expanded slag	
Sydney Steel Corporation	Sydney, N.S.
National Slag Limited	Hamilton, Ont.
Vermiculite	
Eddy Match Company, Limited, Grant Industries Division	Vancouver, B.C.
	Calgary, Alta.
	Regina, Sask.
	Winnipeg, Man.
F. Hyde & Company, Limited	Montreal, Que.
	St. Thomas, Ont.
P. & V. Products	St. Boniface, Man.
Vermiculite Insulating Limited	Lachine, Que.
Western Gypsum Limited	Vancouver, B.C.
Western Insulation Products Ltd.	Edmonton, Alta.
Perlite	
Canadian Gypsum Company, Limited	Hagersville, Ont.
Domtar Construction Materials Ltd.	Caledonia, Ont.
	Calgary, Alta.
Holmes Insulations Limited	Sarnia, Ont.
Laurentide Perlite Inc.	Charlesbourg West, Que.
Perlite Industries Reg'd.	Ville St. Pierre, Que.
P & V Products	St. Boniface, Man.
Western Gypsum Limited	Vancouver, B.C.
Western Insulation Products Ltd.	Edmonton, Alta.
Pumice	
Miron Company Ltd.	Montreal, Que.
Ocean Cement Limited	Vancouver, B.C.
Plants under construction	
Avon Aggregates Ltd.	Minto, N.B.
Enercon Limited	Mississauga, Ont.



PRICES

Expanded clay and shale	$4.50 to $6.50/cu yd
Expanded slag	2.60 to 5.25/cu yd
Exfoliated vermiculite	0.30 to 0.40/cu ft
Expanded perlite	0.30 to 0.40/cu ft

All prices are f.o.b. plant

Aluminum

W. H. JACKSON*

World demand for aluminum strengthened in 1968 and should remain strong throughout 1969 and into 1970.

CANADIAN INDUSTRY

Primary aluminum production in Canada totalled 978,700 short tons in 1968, showing almost no change from 1967. Production in 1969 should exceed one million tons. Export shipments for 1968 increased substantially in comparison with 1967 as listed in Table 1. According to these data, shipments to the United States increased 33 per cent while shipments to all other countries declined 4.5 per cent.

Canadian exports of semi-fabricated products in the category of bar, rods, sheet, etc., were 29,527 tons and have declined for three successive years. Canadian imports in this category amounted to 83,088 tons an increase of 4.1 per cent, mainly sheet products.

Table 3 shows available data on Canadian aluminum consumption at the first processing stage. Canadian demand recovered in 1968 to levels of 1966. Growing requirements of the automotive industry are reflected in the steady growth of aluminum consumption in permanent mould and die castings. The main market for aluminum continues to be in wrought semi-fabricated products, which in order of importance comprise sheet, wire rod, extrusions, forgings and slugs.

Two companies operate aluminum smelters in Canada – Aluminum Company of Canada, Limited (Alcan) and Canadian British Aluminium Company Limited (CBA). Both are affiliated with major international aluminum companies noted for their efficient marketing organizations under competitive conditions. Smelter capacities at the end of 1968 are listed in Table 5.

Alcan increased its annual operating rate from 845,000 at the end of 1967 to 960,000 tons at the end of 1968. Production for 1968 was 872,700 tons. Minor expansion by smelter modernization is in progress. In mid 1967, the company cut back production owing to inventory build-up and market conditions then prevailing. By mid 1968, inventory levels and demand had improved and in September potlines at Kitimat and Alma were reactivated. Alcan is a wholly owned subsidiary of Montreal-based Alcan Aluminium Limited that has fabricating plants in thirty countries and smelters in eight (Canada, Brazil, India, Italy, Norway, Spain, Sweden and Japan). Smelters are under construction in Britain and Australia. At the end of 1968, smelting capacity of Alcan group companies in all countries was 1,666,000 tons.

CBA for the fiscal year ending July 31, 1968, reported production of 102,660 tons compared with 85,686 tons the previous year. The aftermath of a strike in 1967 caused delays in increasing capacity to 115,000 tons annually. Early in 1969 the plant was operating at its effective capacity of 111,000 tons. Initial work began in 1968 on a new 60,000-ton addition which will be completed in late 1970. During 1968, Reynolds Metals Company acquired the interest of The British Aluminium Company, Limited in CBA. The Reynolds group is the second largest fabricator in Canada after Alcan.

*Mineral Resources Branch.

The geographic locations of Canadian smelters in relation to ore supply are shown on the accompanying map. The only alumina plant in Canada at Arvida, Quebec supplies Alcan smelters in this province. It has an alumina capacity of 1.25 million tons annually representing a throughput of bauxite of some 5 million tons. Actual imports of bauxite were half this capacity. Bauxite for this plant is imported from Guyana via Trinidad, and from Surinam. Beginning in 1972, Guinea will be a bauxite source. Other alumina requirements for Alcan smelters are imported from Jamaica, Guyana and Australia. The Baie Comeau smelter of Canadian British Aluminium Company Limited purchases alumina from Reynolds group companies. The alumina originates from Guinea or the Corpus Christi plant in the United States that processes Jamaican ores.

TABLE 1

Canada, Aluminum Production and Trade, 1967-68

	1967		1968p	
	Short Tons	$	Short Tons	$
Production				
Ingot	975,439		978,700	
Imports				
Bauxite ore				
Guyana	1,552,761	14,406,000	1,763,002	15,942,000
Surinam	771,596	8,137,000	668,977	7,154,000
Malaysia	173,786	908,000	50,609	264,000
Australia	–	–	24,697	151,000
United States	4,408	182,000	3,099	140,000
Other countries	58,762	396,000	17	2,000
Total	2,561,313	24,029,000	2,510,401	23,653,000
Alumina				
Jamaica	423,576	26,605,000	412,973	27,898,000
United States	163,793	12,187,000	205,146	14,969,000
Guyana	115,917	7,284,000	122,246	7,979,000
Australia	20,906	1,384,000	92,744	6,309,000
Republic of Guinea	36,392	2,265,000	17,140	1,072,000
Other countries	151	24,000	241	34,000
Total	760,735	49,749,000	850,490	58,261,000
Aluminum and aluminum alloy scrap	9,545	808,000	16,286	1,754,000
Aluminum paste and aluminum powder	587	503,000	610	508,000
Aluminum pigs, ingots, shot, slabs, billets, blooms and extruded wire bars	8,176	4,830,000	15,043	8,831,000
Aluminum castings	1,129	3,108,000	1,047	3,453,000
Aluminum forgings	1,606	4,550,000	1,790	4,079,000
Aluminum bars and rods, n.e.s.	1,526	1,662,000	2,065	1,879,000
Aluminum plates	6,038	5,692,000	8,340	6,651,000
Aluminum sheet and strip up to .025 inch in thickness	8,866	7,393,000	11,840	9,221,000
Aluminum sheet and strip, over .025 inch up to .051 inch in thickness	3,535	3,574,000	3,834	3,644,000
Aluminum sheet and strip, over .051 inch up to .125 inch in thickness	40,446	26,698,000	43,449	28,952,000
Aluminum sheet and strip, over .125 inch in thickness	16,668	10,964,000	10,723	10,658,000
Aluminum foil or leaf	1,026	1,361,000	617	768,000
Converted aluminum foil		1,475,000		1,639,000
Structural shapes, aluminum	1,468	4,387,000	1,122	2,805,000
Aluminum pipe and tubing	435	814,000	549	924,000

TABLE 1 (Cont'd)

	1967		1968P	
	Short Tons	$	Short Tons	$
Imports (Cont'd)				
Aluminum wire and cable, excluding insulated	842	784,000	751	733,000
Aluminum and aluminum alloy fabricated materials n.e.s.		9,171,000		6,711,000
Exports				
Pigs, ingots, shot, slab, billets, blooms and extruded wire bars				
United States	362,713	169,004,000	482,179	225,883,000
Britain	140,960	73,853,000	133,737	71,613,000
Japan	102,261	50,872,000	101,975	45,864,000
Republic of South Africa	18,563	9,739,000	18,878	10,179,000
Brazil	9,923	4,727,000	17,757	8,437,000
West Germany	23,296	10,218,000	15,413	6,853,000
Argentina	10,011	5,062,000	9,826	4,799,000
Belgium and Luxembourg	10,669	5,424,000	9,171	4,645,000
New Zealand	6,711	3,438,000	7,857	3,991,000
Hong Kong	5,241	2,637,000	6,398	3,306,000
Spain	11,807	5,215,000	6,389	2,957,000
Italy	8,164	3,840,000	5,939	2,665,000
Turkey	2,699	1,436,000	5,022	2,521,000
Australia	35	17,000	4,247	2,292,000
Netherlands	3,024	1,484,000	4,028	2,044,000
Other countries	44,572	22,426,000	33,817	17,166,000
Total	760,649	369,392,000	862,633	415,215,000
Bars, rods, plates, sheet, circles, castings and forgings				
United States	9,607	8,411,000	16,816	13,969,000
New Zealand	4,247	2,390,000	4,177	2,391,000
Republic of South Africa	4,449	2,497,000	2,169	1,156,000
France	1,757	1,144,000	1,616	1,126,000
Britain	529	612,000	822	998,000
Jamaica	1,030	788,000	740	585,000
Portugal	443	254,000	676	418,000
Mexico	–	–	550	316,000
Venezuela	1,904	1,221,000	469	377,000
Panama	283	240,000	400	315,000
Other countries	6,422	4,027,000	1,092	2,587,000
Total	30,671	21,584,000	29,527	24,238,000
Foil				
United States	48	51,000	221	240,000
Britain	41	64,000	19	29,000
Mexico	15	20,000	10	17,000
Trinidad and Tobago	2	4,000	4	7,000
Nigeria	17	19,000	3	6,000
Others	108	144,000	16	22,000
Total	231	302,000	273	321,000
Fabricated materials, n.e.s.				
United States	1,939	1,799,000	2,546	2,151,000
Britain	88	149,000	441	587,000
Malaysia	306	241,000	346	268,000
Pakistan	375	224,000	342	239,000

TABLE 1 (Cont'd)

	1967		1968p	
	Short Tons	$	Short Tons	$
Exports (Cont'd)				
Jamaica	717	556,000	264	255,000
Other countries	6,690	4,663,000	1,519	1,856,000
Total	10,115	7,632,000	5,458	5,356,000
In ores and concentrates				
United States	11,355	1,210,000	11,878	1,325,000
Italy	662	64,000	1,153	127,000
Spain	378	75,000	710	136,000
France	–	–	663	74,000
Britain	74	14,000	436	100,000
Other countries	161	49,000	184	36,000
Total	12,630	1,412,000	15,024	1,798,000
Scrap				
United States	36,292	10,188,000	34,352	9,505,000
Italy	11,038	4,287,000	12,240	4,527,000
Japan	2,738	983,000	2,974	1,032,000
West Germany	1,462	433,000	835	208,000
Netherlands	769	265,000	692	174,000
Spain	173	43,000	509	161,000
Other countries	817	257,000	462	150,000
Total	53,289	16,456,000	52,064	15,757,000

Source: Dominion Bureau of Statistics.
pPreliminary; – Nil; n.e.s. Not elsewhere specified.

TABLE 2

Canada, Primary Aluminum Production, Trade and Consumption, 1959-68
(short tons)

	Production	Imports	Exports	Consumption*
1959	593,630	852	507,290	88,787r
1960	762,012	501	552,155	120,831
1961	663,173	636	487,034	135,575
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	975,439	8,176	760,649	217,484
1968p	978,700	15,043	862,633	239,636

Source: Dominion Bureau of Statistics.
*1959 = producers' domestic shipments; 1960 and subsequent years, consumption, including secondary, as reported by consumers.
pPreliminary; rRevised; . . Not available.

WORLD INDUSTRY

Four to five tons of bauxite are required to produce two tons of alumina which in turn produces one ton of aluminum.

World production of bauxite was 50 million tons in 1968, of which 41.8 million was of non-communist origin. The main producing countries in 1968 were: Jamaica (9.3 million tons), Surinam (6.2), Australia (5.5), Guyana (4.1), France (2.9), USSR (5.4), Yugoslavia (2.3), Hungary (2.1), United States (1.9), Greece (1.9), Guinea (2.0), Dominican Republic (1.0), and India (1.0). New mines must precede smelter construction. The aluminum industry has methodically developed ample supplies of bauxite to take care of expansion. Among all the major ores, bauxite is unlikely to be in short supply. The major developments are in reasonable proximity to seacoasts and shipping.

Metal grade bauxite, the main commercial source of aluminum is essentially a mixture of clay minerals derived from the lateritic weathering of aluminous rocks. The clay minerals gibbsite, boehmite and diaspore predominate in such deposits. The minimum permissible alumina content is in the order of 40 per cent and the maximum silica content 5 per cent. Ores

TABLE 3

Canada, Consumption of Aluminum at First Processing Stage
(short tons)

	1965	1966	1967	1968P
Castings				
Sand	1,367	1,665	1,685	1,614
Permanent-mould	7,509	10,945	10,686	12,325
Die	13,202	15,647	17,481	19,747
Other	4,375	9,890*	62	92
Total	26,453	38,147	29,914	33,778
Wrought products				
Extrusions, including tubing	48,589	53,701	51,721	58,507
Sheet, plate, coil and other (including rod, forgings and slugs)	130,318	145,216	126,589**	135,959
Total	178,907	198,917	178,310	194,466
Destructive uses				
Non-aluminum-base alloys, powder and paste, deoxidizers, and other	7,734	6,237	9,260	11,392
Total	7,734	6,237	9,260	11,392
Total consumed	213,094	243,301	217,484	239,636
Secondary aluminum produced	23,570	30,532	34,396	27,407

Receipts and Inventories at Plants	Metal Entering Plants		On Hand Dec. 31	
	1967	1968P	1967	1968P
Primary aluminum ingot and alloys	197,179	207,916	52,528	53,702
Secondary aluminum	21,160	21,265	2,392	2,248
Scrap originating outside plant	37,959	41,147	4,098	3,840

Source: Dominion Bureau of Statistics.
PPreliminary; *Includes smelter busbar; **Includes reroll stock imported from United States.

in which the mineral gibbsite predominates are preferred as less costly processing techniques can be used to recover the alumina content. Other clay minerals such as kaolinite or halloysite containing silica are major impurities. Impurities such as iron oxides, quartz and titanium oxides are less critical as these are essentially inert to the Bayer process of extracting alumina. In prospecting, the amounts of combined water, iron, silica and titanium are determined, the difference being total alumina. Extractable alumina is determined by digestion in caustic soda.

Countries that produced over 0.2 million tons of aluminum ingot in 1968 were: U.S.A. (3.25 million tons), USSR (1.35), Canada (0.98), Norway (0.52), Japan (0.53), France (0.40), West Germany (0.28). Table 4 shows the relative balance between production and consumption among major geographical regions. Within this framework, the main production and trade is among the industrialized countries.

New smelting capacity is increasingly being built in market areas, except where unusual combinations of power, transportation costs, tariffs and the logistics of raw material assembly dictate sites in more remote locations. These locations are becoming increasingly difficult to find in politically stable areas. The advent of nuclear energy increases the range of alternatives and also increases the relative importance of non-technical factors in site location such as various taxes and incentives to encourage smelting.

Canada and Norway have been the major net exporters to world markets and their historic position is unlikely to change in this regard. The graph, Net Exports of Aluminum in 1967, illustrates the importance of the international trade in ingot. As competition for non-captive markets becomes acute during periods of oversupply, the level of world capacity in relation to demand is of particular importance to exporting countries.

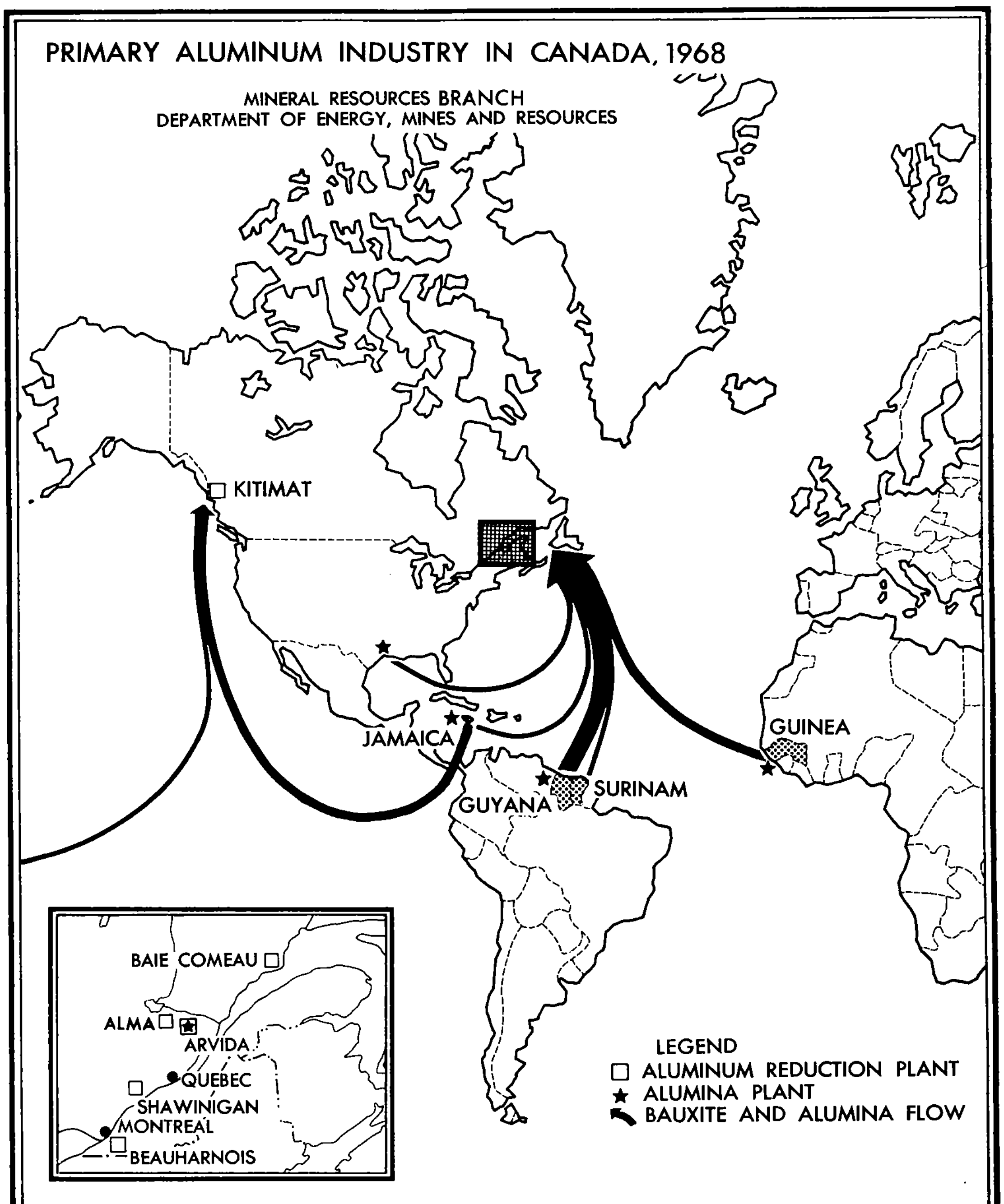

PRIMARY ALUMINUM INDUSTRY IN CANADA, 1968
MINERAL RESOURCES BRANCH
DEPARTMENT OF ENERGY, MINES AND RESOURCES
KITIMAT
JAMAICA
GUYANA
SURINAM
GUINEA
BAIE COMEAU
ALMA
ARVIDA
QUEBEC
SHAWINIGAN
MONTREAL
BEAUHARNOIS
LEGEND
ALUMINUM REDUCTION PLANT
ALUMINA PLANT
BAUXITE AND ALUMINA FLOW

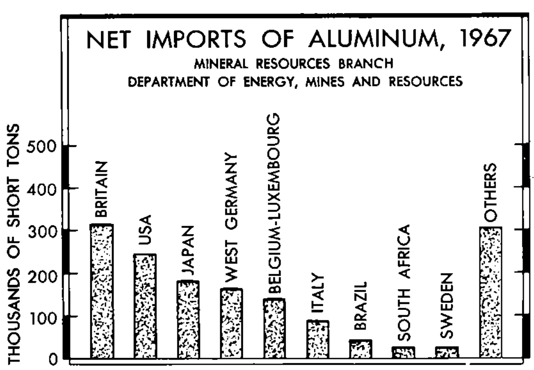
TABLE 4

World Primary Aluminum Production and Consumption, 1968
(thousand short tons)

	Production	Consumption
Canada	979	220
United States	3,255	3,684
Europe	1,921	2,259
Japan	531	696
Australia	107	105
India	132	122
Africa	171	44
Sub-Total (includes countries not listed)	7,236	7,286
Communist countries	1,805	1,730
Total	9,042	9,015

Source: American Bureau of Metal Statistics.

The graph, Net Imports of Aluminum in 1967, illustrates the countries deficient in smelting capacity. In many of them, new capacity is under construction that will equal their 1967 net imports. Owing to anticipated market growth this situation should not be cause for concern but changes in marketing patterns are inevitable. The current high operating rates of existing smelters and short term estimates of capacity increases to 1970 indicate that aluminum industry expansion is adequate but not excessive. The graph showing Aluminum Industry Trends gives an overview which shows that Canadian capacity is not maintaining a growth rate comparable to the world trend.



The world aluminum industry is now larger than in the 1950's or early 1960's so that additions to capacity represent a smaller increase on a proportional basis. Because of the larger scale it is easier for fabricators or other segments of the metal industry to integrate backwards into smelting or even mining. The minimum size of a smelter about 100,000 tons, is easier to justify in terms of markets available to a particular group.

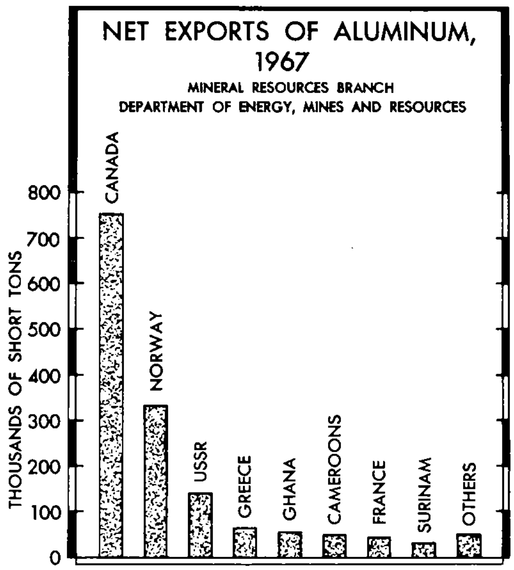
Beyond 1970, industry observers have differing views on whether overcapacity will or will not occur. The pertinent question is whether an average 9 per cent growth rate in consumption can be maintained well into the 1970's. The larger producers normally adjust production to sales and defer construction of new smelters during a period of slow demand but smaller smelters, captive to fabricating plants, are becoming a noticeable part of aluminum industry structure. Their output is not normally sold on world markets to independent consumers. While these considerations will bear watching in the future, it is certain that demand for aluminum will be strong throughout 1969, and consumption of primary aluminum in the non-communist world should approximate 7.9 million tons.

TABLE 5

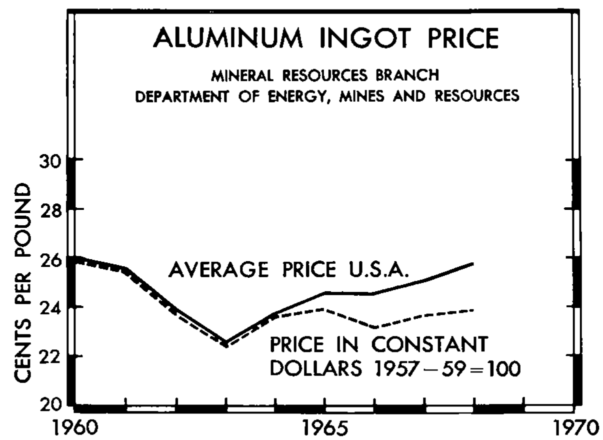
Aluminum Smelter Capacity in Canada Year-end, 1968
(short tons)

Company	Capacity
Aluminum Company of Canada, Limited	
Arvida, Quebec	373,000
Alma, Quebec	115,000
Shawinigan, Quebec	70,000
Beauharnois, Quebec	44,000
Kitimat, British Columbia	280,000
Undistributed increment by modernization	78,000
Canadian British Aluminium Company Limited	
Baie Comeau, Quebec	111,000
Canadian total	1,071,000

The United States represents the largest market for aluminum. It is also the biggest producer and the biggest importer of crude metal. Unwrought imports for 1968 totalled 681,148 tons and crude exports were 180,280 tons. The level of imports was unusually high owing to inventory build-up by consumers in the first half of 1968 and a strike in the domestic industry. Strikes did occur, shutting down about one quarter of the industry for two months and causing a loss of production in the order of 150,000 tons. Sales from the governmental stockpile were only 53,335 tons. At the end of 1968, the stockpile inventory was 1,448,361 tons of which 998,361 tons were available for disposal, being the amount in excess of the 450,000 stockpile objective.



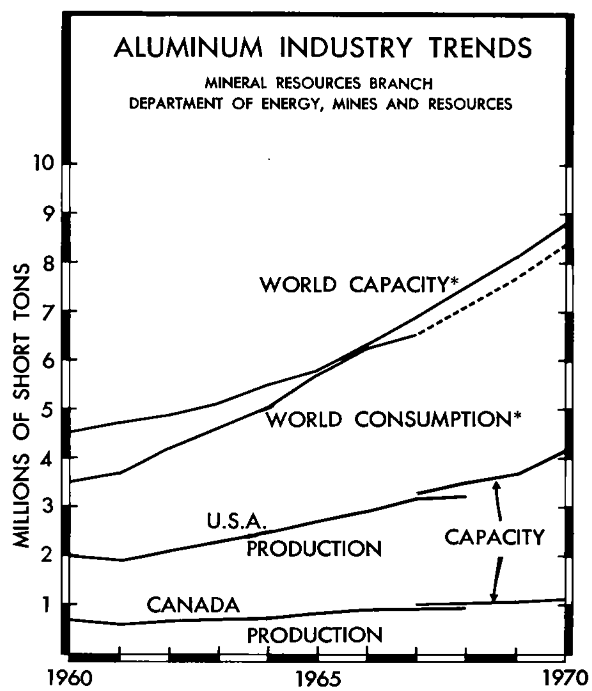
The main destructive uses are as a deoxidizer in steel manufacture, as an alloy with other metals such as magnesium or zinc, and as powder in the manufacture of paint and explosives.



USES

Some 95 per cent of bauxite mined is of metal grade. The remainder has important industrial uses. Chemical grades of bauxite are used for clarifying edible oils, for processing to aluminum sulphate which has a substantial market in sizing paper, and for the manufacture of high alumina cement; calcined bauxite in limited supply is important in abrasives and refractories. Calcined alumina is used in abrasives, ceramics and refractories; the low soda variety in electrical insulators. Hydrated alumina is the basis of aluminum chemicals such as iron free aluminum sulphate, aluminum acetate, aluminum stearate and others. Tabular alumina has applications as catalyst carriers, fillers, pigments, and special refractories. Activated alumina is used to remove moisture from gases.

Aluminum smelter products such as remelt ingot, sheet ingot, extrusion ingot, wire bars etc., are distributed to a number of markets. Aluminum castings have varied end-uses such as automotive parts, electrical appliances and items for structural or decorative purposes. End-uses for sheet include building sheathing, cans, household utensils, foil and slugs for making collapsible tubes. Extrusions are typically used in conjunction with sheet in curtain wall systems of building construction, in the manufacture of trucks, trailer bodies, railway cars, doors and windows, for pipe, and as tubing for lightweight furniture. Aluminum rod goes into the making of electrical wire and cable.



*Excludes Communist Countries.

PRICES

United States producers increased the price for aluminum ingot of 99.5 per cent purity from the former level of 25.0 cents a pound established January 19, 1967 to 26.0 cents a pound on June 1, 1968. A further change in January 1969, increased the price to 27.0 cents a pound.

Canadian prices increased as follows: June 13, 1967, 26.5 cents; June 5, 1968, 27.5 cents; January 18, 1969, 28.5 cents. In all markets other than Canada and the U.S.A., Aluminum Company of Canada, Limited increased prices by one cent a pound to 26.5 cents (U.S.).

The graph, Aluminum Ingot Price, shows the trend from 1960 onwards. The actual price level is again approaching the level achieved in 1960 but in terms of constant dollars, using the General Wholesale Price Index as a deflator, aluminum continues to have a relatively favourable price structure.

TARIFFS

Most Favoured Nation Tariff

	1969*
CANADA	
Bauxite	free
Aluminum oxide and hydroxide	"
Aluminum pigs, ingots, blocks, notch bars, slabs, billets, blooms and wire bars	1¢/lb
Aluminum bars, rods, plates, sheets, strips, circles, squares, discs, rectangles	2.6¢/lb
Aluminum angles, channels, beams, tees and other rolled, drawn or extruded sections and shapes	18½%
UNITED STATES	
Bauxite ore (duty temporarily suspended)	30¢/lt
Unwrought aluminum in coils, uniform cross section not greater than 0.375 inch	2¢/lb
Unwrought aluminum other, excluding alloys of aluminum	1.1¢/lb
Unwrought aluminum alloys, aluminum silicon	1.5¢/lb
Unwrought aluminum alloys, other	1.1¢/lb
Aluminum waste and scrap (duty temporarily suspended)	1.2¢/lb

Source: The Customs Tariff and Amendments, Department of National Revenue and Excise Division, Ottawa; Tariff Schedules of the United States Annotated (1969), TC Publication 272.

*Effective date January 1.

Antimony

J. G. GEORGE*

Canada's production of primary antimony is a by-product of lead smelting operations, principally in the form of antimonial lead, but also as antimonial dross. There has been no production of antimony metal or regulus in Canada since 1944. The antimony content of primary antimonial lead produced in 1968 was 1.12 million pounds compared with 1.27 million pounds in 1967.

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 Mainland 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. A total of 792,700 pounds of antimony oxide were imported in 1968 with Britain supplying over 83 per cent; the remainder came from the United States and Mainland China. Statistics on Canadian exports of antimonial lead are not available.

Cominco Ltd., which operates a lead smelter and refinery and an electrolytic zinc plant at Trail, British Columbia, is the sole producer of primary antimonial lead in Canada. The antimonial lead has a variable antimony content up to 35 per cent, depending on the customers' requirements. Secondary smelters recovered antimonial lead from scrap metal but no recent information is available concerning this production. Shipments of secondary antimonial lead (gross weight) amounted to 24,042 tons in 1966 and 22,235 tons in 1965.

DOMESTIC SOURCES AND OCCURRENCES

The source of most of the antimonial lead produced at Trail is 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, New Brunswick, East Coast Smelting and Chemical Company Limited, a subsidiary of Brunswick Mining and Smelting Corporation Limited, produced 550 tons of antimonial dross in 1968 compared with 1,007 tons in 1967.

Several Canadian occurrences or deposits of the principal antimony mineral, stibnite (Sb_2S_3), have been explored and partially developed, but results generally have not been encouraging. The better known occurrences are in the Atlantic Provinces, Quebec, British Columbia and the Yukon Territory. Proven and probable reserves of Yukon Antimony Corporation Ltd. were reported in 1965 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.

*Mineral Resources Branch.

TABLE 1

Antimony – Canadian Production, Imports and Consumption, 1967-68

	1967		1968p	
	Pounds	$	Pounds	$
Production				
Antimony content of antimonial lead alloys	1,267,686	672,000	1,124,000	596,000
Imports				
Antimony oxide				
Britain	400,800	165,000	661,400	259,000
United States	41,400	16,000	86,800	34,000
Mainland China	88,100	23,000	44,500	13,000
Total	530,300	204,000	792,700	306,000
Consumption				
Antimony regulus (metal) in production of:				
Antimonial lead alloys	802,362		802,484	
Babbitt	123,916		137,325	
Solder	25,606		27,770	
Type metal	174,080		157,421	
Other commodities*	64,215		44,631	
Total	1,190,179		1,169,631	

Source: Dominion Bureau of Statistics.
*Includes foil, bronze, lead-base alloys, drop shot and other minor commodities.
pPreliminary.

TABLE 2

Antimony – Canadian Production, Imports and Consumption, 1959-68
(pounds)

	Production* (all forms)	Imports (regulus)	Consumption** (regulus)
1959	1,657,797	1,170,796	1,135,000
1960	1,651,786	843,794	952,000
1961	1,331,297	832,547	1,029,000
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
1968p	1,124,000	..	1,170,000

Source: Dominion Bureau of Statistics.
*Antimony content of antimonial lead alloy shipped.
**Consumption of antimony regulus (metal) as reported by consumers. Does not include antimony in antimonial lead produced by Cominco Ltd.
p Preliminary; . . Not available.

WORLD REVIEW

World mine production of antimony in 1968, as estimated by the United States Bureau of Mines, totalled 67,200 short tons, 2,800 tons more than in 1967. Antimony is produced from ores and as a smelter byproduct in several countries with the major sources being the Republic of South Africa, Mainland China, Bolivia, USSR, Mexico and Yugoslavia. National Lead Company operates the world's largest antimony smelter for ores and concentrates at Laredo, Texas, where it produces antimony metal, 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 of total antimony supply in the United States and other highly industrialized countries of the world.

Antimony supply and demand were in reasonably close balance in 1968, although at the end of the year metal supply was somewhat on the short side. Although the actual situation in antimony mining and smelting operations in Mainland China is not known, its exports of antimony ore and metal were smaller than in previous years. In 1968, antimony prices in the United States showed little change whereas European prices varied considerably.

The United States in 1968 was again the non-communist world's largest consumer of antimony and continued to depend on foreign supplies for a large portion of its requirements. Antimony metal contained in the United States government stockpile, for conventional war requirements, totalled 49,197 tons as at December 31, 1968, only 174 tons less than at the beginning of that year. The stockpile objective remained at 25,500 tons, leaving a surplus of 23,697 tons. Stockpiled antimonial lead amounted to 10,487 tons at the beginning of 1968 and dropped to 10,336 tons at the end of the year. A stockpile objective has not been established for antimonial lead.

TABLE 3

Canadian Consumption of Antimonial Lead Alloy*, 1966-68
(pounds)

	1966	1967	1968p
Storage batteries	1,892,067	1,863,805	1,975,184
Other uses, including babbitt, solder, type metal	701,666	632,227	149,719
Total	2,593,733	2,496,032	2,124,903

Source: Dominion Bureau of Statistics.
*Antimony content of primary and secondary antimonial lead alloys.
pPreliminary.

TABLE 4

Canadian Consumption of Antimonial Lead Alloy*, 1960-68
(pounds)

1960	2,269,507
1961	2,494,220
1962	2,662,400
1963	2,688,157
1964	2,506,454
1965	2,775,241
1966	2,593,733
1967	2,496,032
1968p	2,124,903

Source: Dominion Bureau of Statistics.
*Antimony content of primary and secondary antimonial lead alloys.
pPreliminary.

USES

The principal use of antimony is as an ingredient in many lead alloys in which it hardens and strengthens lead and inhibits chemical corrosion. It is also used in the form of oxides and salts. Antimonial lead containing from 3 to 12 per cent antimony is used in the manufacture of lead storage batteries. Although this use remained a major outlet for antimony metal, the quantities required continued the downward trend of recent years mainly because of the continued reduction in the antimony content of the antimonial lead consumed. Antimonial lead alloys are also used for sheathing electric cables and in pipe and sheet. Various other alloys containing antimony, lead and other metals are used in the production of type metal, antifriction bearing metal and solder.

TABLE 5

World Mine Production of Antimony, 1966-68
(short tons)

	1966	1967p	1968p
Republic of South Africa	12,534	14,216	15,000
Mainland China	16,500	13,200	*
Bolivia	11,729	12,421	13,000
USSRe	6,900	7,100	*
Mexico	4,868	4,199	3,800
Yugoslavia (metal)	2,916	2,533	2,500
Turkey	3,396	2,240	*
Czechoslovakia	2,200	2,200	*
Morocco	1,480	1,753	*
United States	927	892	880
Canada	703	634	562
Other countries	4,360	3,026	31,458
Total	68,513	64,414	67,200

Source: Dominion Bureau of Statistics for Canada for all three years. Minerals Yearbook 1967, United States Department of the Interior, for other 1966 and 1967 figures, and Commodity Data Summaries, January 1969, Bureau of Mines, United States Department of the Interior, for other 1968 figures.
*Included in "Other countries".
pPreliminary; eEstimated.

Antimony oxide, Sb_2O_3, usually produced directly from high-grade sulphide ore (containing 60 per cent or more antimony), is used extensively as a flame-proofing additive in paints, plastics and fabrics. The trioxide is also used in metalware and ceramic enamels, and as a white pigment in paints. In the ceramics field, antimony adds hardness and acid resistance to enamel coverings for such products as bathtubs, sinks, refrigerators, etc. The pentasulphide of antimony is employed as a vulcanizing agent by the rubber industry.

High-purity antimony metal is used by manufacturers of inter-metallic compounds for semiconductor use. An aluminum-antimony alloy is widely used as a semiconductor in transistors and rectifiers. Also employed by the electronics industry are alloys of antimony which exhibit thermoelectric properties.

A large portion of the antimony requirements of the United States is derived from secondary sources. Secondary production was 24,258 tons in 1966 and 23,664 tons in 1967. These tonnages, added to the amounts of primary antimony consumption shown in Table 6, give a total use in the United States of about 43,940 tons in 1966 and 41,010 tons in 1967.

TABLE 6

Industrial Consumption of Primary Antimony in the United States, by Class of Material Produced (short tons, antimony content)

Product	1966	1967
Metal Products:		
Ammunition	154	209
Antimonial lead	6,285	5,539
Bearing metal and bearings	731	653
Cable covering	164	141
Castings	62	54
Collapsible tubes and foil	44	31
Sheet and pipe	107	118
Solder	155	184
Type metal	515	382
Other	219	223
Total	8,436	7,534
Nonmetal Products:		
Ammunition primers	27	30
Fireworks	50	43
Flameproofing chemicals and compounds	3,188	3,454
Ceramics and glass	2,074	1,884
Matches	*	*
Pigments	832	665
Plastics	2,224	1,785

TABLE 6 (Cont'd)

Rubber products	870	948
Other	1,980	1,007
Total	11,245	9,816
Grand Total	19,681	17,350

Source: United States Bureau of Mines Minerals Yearbook 1967.

*Included with "Other" to avoid disclosing individual company confidential data.

PRICES

The United States domestic price of antimony metal, as quoted in *Metals Week*, in bulk, 99.5 per cent, f.o.b. Laredo, Texas, remained unchanged throughout 1968 at 44.0 cents a pound.

The United States price of imported antimony metal, as quoted in *Metals Week*, in 5-ton lots, 99.5 per cent, f.o.b. New York, 2 cents a pound duty paid, was 41½-42 cents a pound at the beginning of 1968. It remained at this level until about mid-March when it was raised to 43½-44 cents a pound. This higher quotation obtained for the remainder of the year.

TARIFFS*

	Most Favoured Nation
CANADA	
Antimony, or regulus of, not ground, pulverized or otherwise manufactured	free
Antimony oxides	12½% ad val.
UNITED STATES	
Antimony ore	free
Antimony metal, unwrought	1.5¢ per lb.

Sources: The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa.

Tariff Schedules of the United States Annotated (1969) TC Publication 272.

*On and after January 1, 1969

Asbestos

W.G. JEFFERY*

Asbestos output in Canada in 1968 reached a record high level of 1,596,011 tons, an increase of 9.9 per cent from 1967. The total value, at $190,068,054, was also a new high, up 15.1 per cent from 1967. About 86 per cent of the tonnage came from the Province of Quebec, between 4 and 5 per cent from each of the Provinces of Newfoundland and British Columbia and the Yukon Territory and a little over 1 per cent from the Province of Ontario. World fibre demand remained very strong in 1968 and Canada retained its dominant position as the major supplier of asbestos to world markets. Of total exports amounting to 1.46 million tons, the United States absorbed 45 per cent with a value of $70.2 million. Total exports of asbestos manufactured products increased substantially from $2.6 million in 1967 to $3.2 million in 1968.

Asbestos is a commercial term applied to fibrous varieties of several minerals differing in composition, the fibres being diverse in length, strength, flexibility and other factors that lead to variable degrees of usefulness and thus of value. The varieties of asbestos produced commercially are chrysotile, crocidolite (blue asbestos), amosite and anthophyllite. Chrysotile asbestos makes up 90 per cent of world production and trade and this is the only variety that is mined in Canada. Although asbestos is found in practically all countries, its occurrence in satisfactory quality and economic quantity is not common.

The main criterion for assessing different fibre grades is on the basis of length although a combination of tests defining other qualities is becoming more important. The major standard on a length basis is that developed by the industry in Quebec, where asbestos is described and priced by categories from the longest, crude Nos. 1 and 2 through Group 3, down to the shortest Group 7.

Approximately 90 per cent of total world output comes from Canada, USSR and southern Africa. Canada accounts for about 35 per cent of the world's asbestos production and some 70 to 75 per cent of world exports of fibre.

*Mineral Resources Branch.

TABLE 1

Canada – Asbestos Production and Trade, 1967-68

	1967		1968P	
	Short Tons	$	Short Tons	$
Production (shipments)				
By type				
Crude	288	249,684		
Milled fibre	705,295	123,825,044		
Shorts	746,521	41,044,058		
Total	1,452,104	165,118,786*	1,596,011	190,068,054*
By province				
Quebec	1,292,296	136,481,924	1,368,811	151,770,454
British Columbia	92,192	17,670,108	75,000	13,875,000
Newfoundland	63,725	10,499,143	69,000	11,900,000
Yukon	2,260	406,371	64,000	10,240,000
Ontario	1,631	61,240	19,200	2,282,600
Total	1,452,104	165,118,786	1,596,011	190,068,054
Exports				
Crude				
Japan	114	87,000	89	66,000
United States	47	41,000	89	71,000
West Germany	26	22,000	21	20,000
Other countries	42	39,000	3	4,000
Total	229	189,000	202	161,000
Milled fibre (groups 3, 4 and 5)				
United States	201,551	40,109,000	217,805	43,881,000
Britain	64,914	13,949,000	63,850	13,653,000
West Germany	42,371	8,196,000	56,324	12,303,000
Australia	33,297	5,822,000	40,112	7,225,000
France	46,985	9,114,000	39,273	7,615,000
Belgium and Luxembourg	20,646	4,108,000	35,798	6,922,000
Japan	30,267	5,209,000	33,560	5,916,000
Mexico	22,975	4,354,000	26,424	5,040,000
Brazil	18,076	3,458,000	20,403	4,058,000
Netherlands	11,646	2,317,000	18,689	3,848,000
India	13,096	3,019,000	16,534	3,411,000
Spain	18,944	3,830,000	15,189	3,023,000
Italy	12,023	2,407,000	14,128	2,881,000
Austria	5,936	1,162,000	11,308	2,277,000
Other countries	110,553	20,516,000	113,721	21,739,000
Total	653,280	127,570,000	723,118	143,792,000
Shorts (groups 6, 7, 8 and 9)				
United States	406,155	22,870,000	443,436	26,276,000
Japan	76,514	6,957,000	63,831	5,702,000
Britain	45,452	2,707,000	55,304	3,295,000
West Germany	32,110	2,049,000	34,459	2,467,000
France	27,363	1,723,000	19,233	1,245,000
Belgium and Luxembourg	21,463	1,963,000	18,594	1,625,000
Netherlands	8,352	514,000	12,163	733,000
Spain	4,317	385,000	11,213	1,023,000

TABLE 1(Cont'd.)

	1967		1968p	
	Short Tons	$	Short Tons	$
Exports (Cont'd)				
Shorts (groups 6, 7, 8 and 9) (Cont'd)				
Australia	8,640	574,000	11,144	815,000
South Korea	12,412	1,213,000	10,963	1,111,000
Other countries	45,757	3,684,000	55,990	4,654,000
Total	688,535	44,639,000	736,330	48,946,000
Grand total, crude, milled fibres and shorts	1,342,044	172,398,000	1,459,650	192,899,000
Manufactured products				
Brake linings and clutch facings				
United States		46,000		261,000
Cuba		231,000		124,000
Equador		58,000		90,000
Kuwait		30,000		74,000
Lebanon		18,000		41,000
Guatemala		10,000		36,000
France		–		17,000
El Salvador		6,000		17,000
Other countries		163,000		90,000
Total		562,000		750,000
Asbestos and asbestos cement building materials				
United States		799,000		638,000
West Germany		5,000		311,000
Australia		168,000		171,000
Netherlands		108,000		129,000
Pakistan		–		70,000
Japan		66,000		53,000
India		10,000		32,000
Trucial States		–		30,000
Other countries		221,000		81,000
Total		1,377,000		1,515,000
Asbestos and asbestos cement basic products, not elsewhere specified				
United States		450,000		659,000
Britain		25,000		72,000
New Zealand		16,000		53,000
Switzerland		30,000		47,000
Australia		18,000		25,000
Belgium and Luxembourg		6,000		13,000
Jamaica		9,000		13,000
Cuba		–		12,000
Other countries		74,000		36,000
Total		628,000		930,000
Total exports, asbestos mannufactured products		2,567,000		3,195,000

TABLE 1 (Cont'd)

	1967		1968p	
	Short Tons	$	Short Tons	$
Imports				
Asbestos, unmanufactured	7,293	1,281,000	5,932	1,118,000
Asbestos, manufactured cloth, dryer felts, sheets woven or felted		781,000		737,000
Packing		1,010,000		896,000
Brake linings		2,875,000		3,840,000
Clutch facings		354,000		427,000
Asbestos-cement shingles and siding		187,000		229,000
Asbestos-cement board and sheets		969,000		1,011,000
Asbestos and asbestos cement building materials, n.e.s.		1,632,000		1,049,000
Asbestos and asbestos-cement basic products, n.e.s.		1,584,000		1,647,000
Total asbestos, manufactured		9,392,000		9,836,000
Total asbestos, unmanufactured and manufactured		10,673,000		10,954,000

Source: Dominion Bureau of Statistics.
*Does not include value of containers.
pPreliminary; –Nil; n.e.s. Not elsewhere specified.

CANADIAN INDUSTRY AND DEVELOPMENTS

QUEBEC

A chief source of the world's asbestos supply is from the 55-mile-long belt of ultrabasic rocks that stretches through the Eastern Townships of Quebec where asbestos has been mined continuously since 1878. There are ten mines, one underground, one combined underground-open pit, and eight open pits, operated by eight companies. By far the largest mine is Canadian Johns-Manville Company, Limited's Jeffrey open-pit operation at Asbestos, where the concentrating mill can process 32,000 tons of ore a day and produces approximately 45 per cent of all asbestos produced in Canada. The second largest producer is Asbestos Corporation Limited at Thetford Mines with three mines and four milling plants that have a combined capacity of about 25,000 tons of ore a day. Major developments in the Eastern Townships in 1968 included the continued mine and mill expansion at the Jeffrey mine designed to increase fibre production capacity approximately 16 per cent by 1970. Asbestos Corporation announced plans for shaft sinking to develop a new deep-lying asbestos ore body named the 'Penhale'. The company began construction of a new $2 million processing and storage plant to treat asbestos rock from the King-Beaver open-pit mine; completion of the plant is scheduled for August 1969. Lake Asbestos of Quebec, Ltd. continued work on overburden removal to enlarge its open pit at Black Lake, near Thetford Mines. Bell Asbestos Mines, Ltd. was sinking a new shaft which will be equipped with a friction hoist that will bring cars of asbestos rock to the surface to avoid degradation and consequent loss of quality of the fibre by repeated handling of rock underground.

At the close of 1968, the mine of Nicolet Asbestos Mines Ltd. ceased production due to exhaustion of ore.

Elsewhere in Quebec, there are a number of other properties and prospects. Amongst these, one of the most advanced is the Asbestos Hill project of Asbestos Corporation in northern Quebec. After initial development and an expenditure of $25 million the company held the property on a caretaker basis through 1968. Some consideration has been given to the feasibility of a plant to produce 50,000 tons of fibre a year, a 50 per cent reduction from the original plans of 100,000 tons a year, in an effort to keep capital investment costs to a minimum. McAdam Mining Corporation

Limited carried out milling tests and feasibility studies on an asbestos deposit at Chibougamau, Quebec, that is estimated to contain 90 million tons of rock grading 3.87 per cent asbestos. Abitibi Asbestos Mining Company Limited carried out exploration work on an asbestos property in Maizerets Township, Quebec.

TABLE 2

Canada – Asbestos Production and Exports, 1959-68
(short tons)

Production*	Crude	Milled	Shorts	Total
1959	432	404,019	645,978	1,050,429
1960	330	483,183	634,943	1,118,456
1961	163	548,230	625,302	1,173,695
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
1968p	..	..	..	1,596,011
Exports				
1959	416	401,583	611,923	1,013,922
1960	241	458,053	610,199	1,068,493
1961	176	527,324	589,380	1,116,880
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
1968p	202	723,136	736,330	1,459,668

Source: Dominion Bureau of Statistics.
*Producers' shipments.
pPreliminary; .. Not available.

NEWFOUNDLAND

Advocate Mines Limited operates an open-pit asbestos mine at Baie Verte, Newfoundland. The mine is managed and operated by Canadian Johns-Manville, the major shareholder in a consortium that includes European interests. In 1968 ore reserves were reported at 67 million tons, a substantial increase from 55 million tons reported in 1967.

BRITISH COLUMBIA

The open-pit mine of Cassiar Asbestos Corporation Limited at Cassiar, British Columbia was the sole asbestos mine in western Canada until late 1967 when the company opened a new mine in the Yukon. Cassiar production in 1968 was 75,742 tons of asbestos. The Cassiar fibre is high quality both in overall length and in its low iron content.

YUKON TERRITORY

The Clinton Creek Mine of Cassiar Asbestos Corporation Limited in the Yukon Territory, 50 miles northwest of Dawson City and 7 miles from the Alaska boundary, completed its first full year of operation in 1968. This mine is the most northerly open-pit operation in Canada and despite some cold weather operating difficulties fibre production for the year was 64,279 tons. The mill capacity is 90,000 tons of fibre a year.

ONTARIO

Production on an initial tune-up basis began from the Reeves Mines near Timmins, Ontario. This mine is operated by Johns-Manville Mining and Trading Limited, a subsidiary of Canadian Johns-Manville Company, Limited. The mine and mill was designed to produce 37,000 tons of fibre a year from ore mined at the rate of 5,000 tons a day. Late in 1968, Johns-Manville began an exploration shaft to investigate a deposit in Garrison Township, Ontario, east of Matheson and some 16 miles east of the company's former Munro Mine.

The mill of Hedman Mines Limited at Matheson, Ontario, designed for a milling rate of 300 tons a day, was almost completed at the end of 1968.

Throughout Canada several other asbestos properties are being explored and assessed as to their economic possibilities.

WORLD REVIEW

Total world asbestos production for 1968 is estimated to have reached 4.5 million tons. Of this total Canada accounted for about 36 per cent; USSR, 44 per cent; South Africa, 10 per cent; and others 10 per cent.

Varying estimates of world asbestos production arise from the reporting of Russian output where commonly the short fibre output figures are listed separately from the longer fibre production figures. For comparison with Canadian and other world production all Russian production including their short fibre is here considered. USSR has been for the last few years the largest world producer. The largest Russian asbestos deposits are in the vicinity of Asbest about 40 miles east of Sverdlovsk in the central Ural Mountains. This region produces about 90 per cent of all Russian output. All the mines are open pits and there are four processing mills. A large new mill was due to be completed in 1968. Other producing areas are at Dzetygara about 150 miles southwest of Kustenai in northern Kazakh Republic, and at Aktovrak in the Tuva region toward the Mongolian border where mill expansion was taking place in 1968. There are other developing deposits. Among them, a mill is under construction at the Kiyembay deposit in the Orenburg region of the southern Urals. All these are chrysotile deposits; some antophyllite is produced from the Sysertsk deposit, Sverdlovsk region.

A recently published total production for 1967 is 1,829,000 metric tons, or 2,015,000 short tons, of seven grades. No firm production figures are known for 1968 but it is estimated that production was in the order of 2 million short tons. The Soviet construction industry consumes over 80 per cent of asbestos production, largely for asbestos-cement construction materials. The USSR has exported about 15 per cent of production in the last few years. Export figures recently released by the Soviet Ministry of Foreign Trade show that this proportion was maintained in 1967 with exports of 285,200 metric tons. Russian asbestos was exported to 30 countries, the leading buyers being France, East and West Germany, Poland, Czechoslovakia, Japan, Bulgaria, and Hungary, each with purchases greater than 10,000 metric tons of fibre.

Asbestos production from southern Africa includes chrysotile, crocidolite and amosite. Republic of South Africa is the world's major producer of crocidolite or blue asbestos although this fibre forms less than 10 per cent of world trade. There have been some expansions and developments in 1968 at South African asbestos mines, and exploration leases were arranged in neighbouring Swaziland which has one chrysotile asbestos mine currently in production. Rhodesia has not published production figures since 1965. For the region of southern Africa it is estimated that total asbestos production amounted to about 455,000 tons in 1968, this total combining about 260,000 tons from the Republic of South Africa, 150,000 tons from Rhodesia and 45,000 tons from Swaziland.

TABLE 3

Canada, Asbestos Producers, 1968

Company	Location	Mill Capacity tpd	Remarks
Canadian Johns-Manville Company, Limited			
Jeffrey Mine	Asbestos, Que.	32,000	Open pit. Mill expansion for further 100,000 tons fibre a year by 1970.
Asbestos Corporation Limited			
British Canadian Mine	Black Lake, Que.	11,200	Open pit. Two milling plants.
King-Beaver Mine	Thetford Mines, Que.	8,000	Underground and open pit. New $2 million replacement processing plant.
Normandie Mine	Black Lake, Que.	6,000	Open pit.
Bell Asbestos Mines, Ltd.	Thetford Mines, Que.	3,000	Underground. Sinking new shaft.
National Asbestos Mines Limited	Thetford Mines, Que.	3,500	Open pit.
Lake Asbestos of Quebec, Ltd.	Black Lake, Que.	6,000	Open pit. Expanding pit.
Flintkote Mines Limited	Thetford Mines, Que.	2,000	Open pit.
Carey-Canadian Mines Ltd.	East Broughton, Que.	4,000	Open pit.
Nicolet Asbestos Mines Ltd.	Norbestos, Que.	2,500	Open pit.
Advocate Mines Limited	Baie Verte, Newfoundland	6,000	Open pit.
Cassiar Asbestos Corporation Limited			
Cassiar Mine	Cassiar, British Columbia	2,400	Open pit.
Clinton Creek Mine	Clinton Creek, Yukon Territory	3,000	Open pit. First year of operation in 1968.
Johns-Manville Mining and Trading Limited			
Reeves Mine	Timmins, Ont.	5,000	Open pit. Mill tune-up in 1968.
Hedman Mines Limited	Matheson, Ont.	40	Pilot plant in 1968. 300 tpd fiberizing mill built.

TABLE 4
World Production of Asbestos, 1967-68
(short tons)

	1967	1968[e]
USSR	2,015,000	2,000,000
Canada	1,452,104	1,596,011[p]
Republic of South Africa	268,483	260,530[p]
China	170,000	170,000
Rhodesia	150,000	150,000
United States	123,189	121,000[p]
Italy	111,015	110,000
Swaziland	42,000	45,000
Other countries	60,000	60,000
Total	4,392,000	4,512,000

Source: Publications of the U.S. Bureau of Mines, other trade journals and Novosti Press Agency, Moscow.
[p]Preliminary; [e]Estimated.

Of the remaining world sources of asbestos there has been no indications of significant production increases in 1968. Production for 1968 from China, Italy and United States is estimated to have been much the same as in 1967; 170,000 tons, 110,000 tons and 120,000 tons respectively. In the United States asbestos is mined in California, Arizona, North Carolina and Vermont, with over 50 per cent of production from California. United States production is approximately 16 per cent of its consumption. From other countries the production of asbestos totals between 60,000 and 70,000 tons. Some developments in 1968 included investigation of asbestos deposits in Bolivia and Greece, and also detailed exploration of a chrysotile asbestos deposit in Australia by Canadian mining interests.

Current producing mines throughout the world are operating close to capacity and world demand is growing. Although some expansion is taking place in other countries, the major developments required to supply world needs are taking place or will be carried out in the Canadian asbestos industry.

MARKETS AND TRADE

Asbestos is of use in industry because of its shape as a slender fibre, other physical characteristics and chemical stability. Asbestos has durability and resists weather, corrosion, heat, acids, and vermin and fungi-growth; it insulates against heat, vibration, electricity and sound; its fibrous form helps to bind fillers, rubber, asphalt and cement, the latter being a most important material in that more than 50 per cent of the world's asbestos production is used in asbestos-cement products. Asbestos fibre is used for filtration of acids, alkalies and a great variety of liquids; it can be sprayed, moulded with plastics or glass, and dispersed in fluids, greases, adhesives and sealing compounds.

The fibre is prepared from the ore by a dry milling process consisting of crushing, impact milling, fiberization and separation in its different grades or groups of fibre largely based on length. The major uses of these asbestos grades by their groups is:

Grades No. 1 and 2 (+ ¾ inch and 3/8 to ¾ inch): long spinning fibre for textiles, electrical industry, felted laminates in moulded resin panels.
Group 3 milled fibre: textiles, papers, packings. brake linings, clutch facings, pipe coverings. insulating blocks.
Groups 4 and 5 milled fibres: papers, pipe coverings, packing, gaskets, millboards, roof coatings, plastics, asbestos-cement shingles, flat and corrugated sheets, pipe.
Group 6 shorts: asbestos-cement products, papers, brake linings, coatings, putties and plastics.
Groups 7 and 8 shorts: insulating cement, coatings, putties, paints, welding rods, floor tile, acoustical plaster, greases, oil well muds, mineral fillers.

Consumers and producers are improving quality control in order to define asbestos quality by features other than length of fibre. The physical characteristics include bulk (determined by volume and density measurements), oil and water absorption, surface area (termed openness), fibre separation (termed crudiness), colour, and strength (for asbestos-cement products). Other special tests involve air classification, and the measurement of dust and grit content, viscosity, moisture, sag, plastic index, penetration and magnetic rating. These tests combined with group standards based on length and strict consumer specifications have led to the development of over 100 grades of asbestos.

Consumption of asbestos in Canada in 1968 was in the order of 70,000 tons; less than 5 per cent of production. The balance of production is exported to more than 80 countries around the world. The United States takes about 45 per cent of Canadian exports. This large market has been essentially stable over the past decade; exports from Canada increased from 582,000 tons in 1958 to 608,000 tons in 1967. A future growth of about 2 per cent annually is expected in the United States. From 1958 to 1967, the west European market has expanded rapidly with a 150 per cent increase in imports of Canadian fibre; the European Economic Community countries now import more than 200,000 tons and Britain about 125,000 tons a year. It is estimated that growth in western Europe will be in the order of 5 per cent annually. In 1968, there was an increase of Canadian asbestos sales to the east European countries of Poland, Romania, Bulgaria and Yugoslavia; future sales to this region are likely to fluctuate depending upon the level of imports from the USSR. Asbestos from Canada provides about 48 per cent of Japan's fibre imports and Canadian sales have steadily increased to a level of about 100,000 tons a year. Japan's asbestos market is expected to grow at an annual rate of between 8 to 10 per cent.

Asbestos products and in particular asbestos-cement products used in home and industrial construction remain in high demand. Being fireproof and resistant to corrosion and humidity, asbestos-cement products are especially suitable for use in tropical areas. Domestic manufacture of these building products in the developing countries utilizes the local cement industry and local labour with relatively low bulk amounts of raw material being imported. Markets for Canadian fibres in the developing nations are estimated to have a potential growth rate as high as 10 per cent annually.

OUTLOOK

World consumption of asbestos is expected to grow approximately 4 per cent in 1969 and all indications are that this growth will persist into the early 1970's. The Canadian asbestos industry will remain heavily dependent upon demand from the United States to consume the bulk of our exports, whereas the largest increase in demand is expected from Japan and developing nations. The future pattern of Russian trade is hard to assess, their industry making asbestos-cement products for construction has consumed over 80 per cent of their production for several years and indications are that this pattern will continue. Nevertheless Russian production and internal consumption at a level close to 2 million tons annually has become so large that any changes in building modes or rapid expansion of fibre output could release fibre for additional exports in amounts relatively small in terms of USSR output but of considerable significance in world trade.

Current world production is close to mine capacity and is in near-balance with world consumption. This situation is expected to continue into the early 1970's.

PRICES

Overall price levels of asbestos in Canada increased 2 per cent in mid-1968. Including this price increase, the average price increase on major asbestos grades has been 14 per cent over the decade from 1958 to 1968. Towards the end of the year, major producers in Quebec announced further price increases of 5 to 10 per cent, effective January 1, 1969.

Canadian asbestos prices quoted in "Asbestos" were as follows:

	As of Jan. 1, 1968	As of April 1, 1968	As of Jan. 1, 1969
f.o.b. mines, Quebec			
per short ton			
Crude, No. 1	$1,410.00	$1,410.00	$1,480.00
" No. 2	760.00	760.00	800.00
Group No. 3 (spinning fibre)	360.00	367.00	385.00
	to 588.00	to 600.00	to 630.00
Group No. 4 (shingle fibre)	198.00	201.00	212.00
	to 335.00	to 341.00	to 360.00
Group No. 5 (paper fibre)	140.00	143.00	152.00
	to 165.00	to 169.00	to 180.00
Group No. 6 (waste, stucco or plaster)	101.00	104.00	110.00
Group No. 7 (refuse or shorts)	47.00	45.00	50.00
	to 85.00	to 87.00	to 92.00
Cassiar, f.o.b. North Vancouver, B.C.			
per short ton			
AAA grade (nonferrous spinning fibre)	$ 810.00		$ 845.00
AA grade (")	643.00		673.00
A grade (") Canadian Group 3	484.00		508.00
AC grade (asbestos-cement – Canadian group 4)	345.00		363.00
AK grade (shingle fibre – Canadian group 4)	241.00		249.00
CP grade (shingle fibre – Canadian group 4)	220.00		234.00
AS grade (shingle fibre – Canadian group 4)	200.00		217.00

	As of Jan. 1, 1968	As of April 1, 1968	As of Jan. 1, 1969
CT grade (shingle fibre – Canadian group 4)	$195.00		$211.00
AX grade (shingle fibre – Canadian group 5)	177.00		193.00
CY grade (shingle fibre – Canadian group 5)	126.00		136.00
AY grade (shingle fibre – Canadian group 5)	126.00		136.00

TARIFFS

Item No.	Most Favoured Nation Before Jan. 1, 1968	On and After Jan. 1, 1968	On and After Jan. 1, 1969
CANADA			
31210-1 Asbestos, crude	free	free	free
31215-1 Asbestos yarns, for use in manufacture of clutch facings and brake linings	12-½%	11-½%	10-½%
31200-1 Asbestos in any form other than crude, and all manufactures thereof, n.o.p.	12-½%	12-½%	12-½%
31220-1 Asbestos woven fabrics, for use in the manufacture of clutch facings and brake linings	12-½%	12-½%	12-½%
UNITED STATES			
518.11 Asbestos, not manufactured, crudes, fibres, stucco, sand and refuse	free	free	free
518.21 Asbestos yarn, slivers, rovings, wick, rope, cord, cloth, tape and tubing	8%	7%	6%

Source: The Customs Tariffs and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa. Tariff Schedules of the United States, Annotated (1969), T.C. Publication 272.

Barite

W.G. JEFFERY*

Production of barite in Canada in 1968 was 137,699 tons valued at $1,581,129, a tonnage decrease of 20 per cent from 1967. The main reason for a decline in production was a fire in the surface buildings of the mine in Nova Scotia which produces about 90 per cent of Canada's barite output.

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.

Barite deposits are widespread throughout the world and it is mined in many countries, principally United States, followed by West Germany and Mexico. Canada is approximately sixth in world production and about 90 per cent of the output is exported, mainly as crude barite, to grinding plants in the United States.

The outlook through 1969 and 1970 is for increased production of barite in Canada. World production will depend upon the vitality of petroleum exploration and development throughout the world.

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 or reddish in colour. Barite was produced only in Nova Scotia and British Columbia in 1968.

The mine at Walton, Nova Scotia, operated by Dresser Minerals Division of Dresser Industries, Inc. is the main producer of barite in Canada. Barite ore is extracted from a large replacement deposit by a block caving method and hoisted through the same shaft as lead-zinc-silver sulphides mined in conjunction with barite ore. 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 grinding plants in Louisiana and Texas. A small proportion of the barite is crushed, classified, ground, pulverized and bagged for sale either in domestic markets or for shipment to Caribbean countries. Some barite is recovered in the flotation processing of the argentiferous sulphides.

Fire destroyed a large part of the processing plant in February 1968 and production was suspended while the plant was rebuilt which was completed by August. During the shutdown period the shaft was deepened a further three levels from 1,370 feet to about 1,700 feet.

In British Columbia, Mountain Minerals Limited mines barite underground from vein deposits near Parson and Brisco in the eastern part of the province. Lump ore is shipped by rail to the company's grinding plant at Lethbridge, Alberta. Also in British Columbia, Baroid of Canada, Ltd., recovers barite from tailings at an abandoned lead-zinc mine near Spillimacheen, south of Golden. The tailings are fed as a slurry to separation tables and the barite concentrate is dewatered and shipped by rail for further processing in a grinding plant at Onoway, Alberta.

*Mineral Resources Branch.

TABLE 1

Canada, Barite Production, Trade and Consumption, 1967-68

	1967		1968p	
	Short Tons	$	Short Tons	$
Production (mine shipments)	172,270	1,573,370	137,699	1,581,129
Imports				
United States	5,800	299,000	7,841	375,000
West Germany	94	4,000	60	3,000
Britain	30	2,000	–	–
Total	5,924	305,000	7,901	378,000
Exports				
United States	137,781	1,260,000	110,638	1,041,000
Venezuela	6,382	59,000	2,997	28,000
Trinidad-Tobago	1,940	36,000	2,856	53,000
Total	146,103	1,355,000	116,491	1,122,000
	1966		1967	
Consumption[1]				
Well drilling	12,223		16,000e	
Paints	1,632		1,437	
Glass	896		935	
Rubber goods	158		224	
Other[2]	275		528	
Total	15,184		19,124	

Source: Dominion Bureau of Statistics.
[1]Available data reported by consumers. [2]Includes ceramic products, soaps and detergents.
pPreliminary; – Nil; eEstimated.

During 1968, Mountain Minerals Limited moved ahead with plans to process tailings from the now inoperative Mineral King base-metal mine. Production is planned to begin in late 1969 from a new plant similar to that at the Baroid operation. Barite concentrate will be trucked 24 miles to rail at Invermere, British Columbia for shipment to the company's grinding plant at Lethbridge, Alberta.

There are many occurrences of barite across Canada in most provinces. 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.

During 1968 there was continued interest in the Lake Ainslie deposit on Cape Breton Island where it was reported that there is three million tons of ore grading 44 per cent barite and 17 per cent fluorspar. Plans were announced to develop the Brookfield barite deposit in conjunction with plans to mine celestite ($SrSO_4$) from a Cape Breton Island deposit. The ores from both places will supply a proposed plant at Sydney, Nova Scotia to manufacture barium carbonate and strontium compounds.

In Ontario, Extender Minerals of Canada Limited, subsidiary of L.V. Lomas Limited, constructed facilities for extraction of barite from a vein deposit on the west shore of Mistinikon Lake, Yarrow Township, about six miles southwest of Matachewan.

USES, CONSUMPTION AND TRADE

The dominant use for barite is as a weighting agent in oil and gas well drilling muds where its high specific gravity assists in counteracting high oil and gas pressures. 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.

TABLE 2

Canada, Barite Production, Trade and Consumption, 1959-68
(short tons)

	Production[1]	Imports	Exports	Consumption[2]
1959	238,967	1,662	221,721	22,408
1960	154,292	2,021	134,972	25,483
1961	191,404	1,889	171,696	18,723
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[e]
1968[p]	137,699	7,901	116,491	..

Source: Dominion Bureau of Statistics.
[1]Mine shipments. [2]Available data on consumption reported by consumers.
.. Not available; [e]Partially estimated; [p]Preliminary.

Available data reported by consumers indicated that 19,124 tons of barite were consumed in Canada of which about 16,000 tons, or 84 per cent, was consumed in drilling muds. The next three most important uses are in the paint industry, glass 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 1967 was 7.5 per cent of total consumption, a figure of 1,437 tons.

The glass industry uses barite to increase the workability, act as a flux, assist decolouration 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 1967 is estimated at 1,000 tons or 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 would be whiteness and particle size range. Some requirements, perhaps where weight is most desired, would allow use of off-white material. In 1967 approximately 1.2 per cent of Canadian consumption, 224 tons, was reported consumed as a filler in rubber goods.

The balance of Canada's barite consumption of approximately 500 tons or 2.8 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 although there are plans for the production of barium carbonate. The consumption of barite as feed for a barium chemicals industry is not large – the same order as usage in industries other than oil well drilling. 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 substituted 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 per cent Fe_2O_3.

Canada exports about 90 per cent of production almost wholly to United States. In line with lower production in 1968 exports were down to 116,491 tons from 146,103 in 1967. Imports at 7,901 tons were the highest on record and consisted mainly of ground high-quality barite.

TABLE 3

Canada – Barium Compounds, Imports, 1966-68

	1966[r]		1967[r]		1968	
	Short Tons	$	Short Tons	$	Short Tons	$
Imports						
Lithopone (70% $BaSO_4$)	218	31,000	316	44,000	404	53,000
Barium carbonate	3,623	321,000	3,952	316,000	3,495	304,000

Source: Dominion Bureau of Statistics.
[r]Revised.

WORLD REVIEW

There is world wide 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 1968 was estimated at 3.9 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 controlled by transportation costs to market.

TABLE 4

World Production of Barite, 1967-68
(short tons)

	1967	1968[e]
United States	944,082	938,000
West Germany	428,000	430,000
Mexico	223,000	225,000
USSR	287,000	. .
Canada	172,270	137,699
Italy	171,000	170,000
Greece	. .	. .
Ireland	. .	. .
China	110,000	. .
Peru	110,000	110,000
Morocco	100,000	100,000
Yugoslavia	99,000	100,000
France	95,000	95,000
Other countries	1,150,648	1,562,301
Total	3,890,000	3,868,000

Source: U.S. Bureau of Mines Minerals Yearbook 1967 and U.S. Bureau of Mines Commodity Data Summaries January 1969.
[e]Estimated; . . Not available.

In the United States, production of almost one million 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. For 1967 in United States ground barite was consumed in well drilling, 81 per cent; paints, 5 per cent; glass, 8 per cent; rubber goods, 3 per cent; and other uses, 3 per cent. In addition the barium chemicals industry absorbed about 170,000 tons of crude barite, or about twice the consumption in the glass industry.

During 1968 a mine in Nevada began production hauling crude ore 65 miles to Tonopah for further treatment. In Alaska a small grinding facility was started at the mouth of the Kenai River supplied from the open-pit mine near Petersburg. This was built to supply local demand for weighting agent barite.

In Europe, where dependence on use in well drilling has not been so prominent, consumption varies but the paint and barium chemicals industries are sufficiently large to absorb substantial quantities of barite.

Output in Italy increased 33 per cent over 1967, largely from concentrates from lead-zinc mines in Sardinia. At the end of the year there were plans to re-open an old disused mine near Charleroi, Belgium. There was also an announcement that the Settlingstones mine, Yorkshire, England – for many years the world's only producer of witherite, natural barium carbonate, would close in 1969. This mine originally produced lead but since 1872 had supplied high grade witherite.

Drilling mud barite was in demand in Australia and interest developed in increasing production from the main area in the Flinders Range, South Australia.

In Africa, a United States AID team discovered extensive and promising barite deposits in Liberia.

The Middle East is a major market for barite and additional supplies became available from a new lead mine 150 miles southwest of Teheran which is producing barite concentrates.

Late in 1968 International Minerals & Chemical Corporation and local Thai interests agreed to establish a new mine and mill on extensive high-grade deposits in the southern part of Thailand.

OUTLOOK

Canadian barite output in 1969 is expected to increase over 1968 levels with resumption of production in Nova Scotia. Growth of oil exploration in the Canadian north should provide a strong base for marketing the relatively small production of barite from western Canada. Prices are expected to remain at current levels.

PRICES

According to *Engineering and Mining Journal* of December 1968, prices in the United States were:

Chemical grade	
Hand-picked, 95% $BaSO_4$, 1% Fe	\$20 - 20.50
Flotation or magnetic separation 97-98% $BaSO_4$, 0.3 - 0.5% Fe	25 - 26.50
Add \$3 for 100-lb bags	
Water ground; 99½% $BaSO_4$, 325 mesh, in 50-lb bags	45 - 49
Drilling mud grade, 83-93% $BaSO_4$, 3-12% Fe, specific gravity 4.2 to 4.3	
Crude, in bulk	\$12 - 16
Ground	23 - 26
Imported, 4.2 - 4.3 specific gravity, crude, bulk, c.i.f. Gulf ports	10 - 14
from Canada, long tons, in bulk, crude, f.o.b. shipping point	11
Ground, short tons, in 100-lb bags f.o.b. shipping point	16.50

TARIFFS

CANADA	Most Favoured Nation	
Item No.	Jan. 1, 1968	Jan. 1, 1969
49205-1 Drilling mud and additives	free	free
68300-1 Barytes	18%	16%
92842-1 Barium carbonate	15%	15%
93207-5 Lithopone	12½%	12½%

UNITED STATES		
Item No.		
472.02 Barium carbonate, natural, crude	free	free
472.04 Barium carbonate, natural, ground	11%	10%
472.10 Barium sulphate, natural, crude	\$2.29/l.t.	\$2.04/l.t.
472.12 Barium sulphate, natural, ground	\$5.85/l.t.	\$5.20/l.t.

Sources: The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa. Tariff Schedules of the United States Annotated (1969) TC Publication 272.

Bentonite

W.G. JEFFERY*

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 its 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 bentonites also possess a high dry-bonding strength, especially at elevated temperatures, and this ceramic feature is important in some uses for bentonite.

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

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

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

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.

* Mineral Resources Branch.

TABLE 1

Canada, Bentonite Imports and Consumption, 1967–68

	1967		1968	
	Short Tons	$	Short Tons	$
Imports				
Bentonite				
United States	208,998	2,045,000	292,699	2,664,000
Greece	10,864	109,000	15,000	161,000
Total	219,862	2,154,000	307,699	2,825,000
Activated clays and earths				
United States	6,277	838,000	6,206	905,000
France	218	79,000	138	48,000
West Germany	15	16,000	–	–
Total	6,510	933,000	6,344	953,000
Fuller's earth				
United States	9,079	259,000	9,050	263,000
Grand total	235,451	3,346,000	323,093	4,041,000

	1967	1968^e
	short tons	
Consumption* (available data)		
Pelletizing iron ore	150,000^e	200,000
Well drilling	30,648	
Iron and steel foundries	30,975	
Ceramic products and refractories	679	
Paper	321	
Other uses**	3,005	
Total	215,628	266,000

Source: Dominion Bureau of Statistics.
* Includes fuller's earth.
** Includes bentonite used in the manufacture of paints, rubber products, cleaners and polishers; in the refining of mineral and vegetable oils; and in the pelletizing of stock feeds and base metal concentrates.
– Nil; ^{e} Estimated.

In Manitoba, Pembina Mountain Clays Ltd. mines non-swelling 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 decolourizing and purifying mineral vegetable oils, animal fats and tallows.

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 have 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.

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 use as a binder in the pelletizing of iron mineral concentrates. About 18 pounds is used in every long ton of concentrate to provide the pellet with sufficient "green" strength to withstand handling during the drying and firing stages. The amount of bentonite required varies with the mineralogy and particle size of the concentrate.

TABLE 2

Canada, Bentonite* Imports and Consumption, 1959-68

	Imports		Consumption
	Short Tons	$	Short Tons
1959	..	1,082,593	61,627
1960	..	1,590,441	64,871
1961	..	1,528,170	63,268
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[p]	323,093	4,041,000	266,000[e]

Source: Dominion Bureau of Statistics.
* Includes fuller's earth and activated clays and earths.
.. Not available; [e] Estimated.

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. Non-swelling bentonite is also used as a binder in some low-temperature foundries.

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

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

Activated bentonite is used in decolourizing 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. In 1968 about 200,000 short tons were used by the iron ore industry, compared with an estimated 150,300 tons in 1967. Two new pellet plants began production in 1968 and, in addition, the plant of Steep Rock Iron Mines Limited, previously not using any material for pellet binding, began using bentonite.

Consumption of bentonite in well drilling in the oil and gas industry is subject to considerable fluctuation but only occasionally would be expected to rise to more than 50,000 tons annually in Canada. Iron and steel foundries require bentonite as a binder for moulding sands; approximately 30,000 tons were used in Canada in 1967. Other uses for bentonite consumed relatively small amounts which are estimated to have remained at about the same levels in 1968 as in 1967.

Imports of bentonite in 1968 from the United States increased about 40 per cent over those in 1967 reflecting increased consumption for iron pelletizing. Further shipments from Greek deposits were imported as the assessment of this material continues by pelletizing companies. 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. Non-swelling bentonite, fuller's earth and bleaching clays are produced in numerous States, the major ones being Florida, Georgia, Mississippi and Texas.

United States bentonite production capacity increased in 1968. In other parts of the world there was development of New Zealand bentonite deposits, discovery of deposits in Australia, and exploration activity in South Africa and the Mediterranean area.

OUTLOOK

The bulk of Canada's bentonite consumption is used in pelletizing iron concentrates and suitable bentonite will continue to be imported from United States. As the surge of building new pelletizing capacity has slowed in the last year, imports in 1969 and 1970 will increase only slightly above the level of 1968. Canadian production and consumption in industries other than iron pelletizing will remain at roughly the same levels.

PRICES

United States bentonite prices quoted in *Oil, Paint and Drug Reporter,* December 30, 1968 were as follows:

Bentonite, domestic 200 mesh, bags, car lots, f.o.b. mines	– per ton $14.00
Bentonite, imported Italian, white, high gel, bags, 5-ton lots, ex-warehouse	– per ton $91.00

TARIFFS

CANADA

Item No.		Most Favoured Nation	
		Jan. 1/68	Jan. 1/69
29500–1	Clays, not further mfg. than ground	free	free
93803–2	Activated clay – for refining oils	10%	15%
	– other	20%	15%

Source: The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa.

UNITED STATES

Item No.			Jan. 1/68	Jan. 1/69
521.61	Bentonite	per lt.	73¢	65¢
521.87	Clays, artificially activated		0.09¢/lb +11%	0.08¢/lb +10%

Source: Tariff Schedules of the United States Annotated (1969), TC Publication 272.

Bismuth

J.G. GEORGE*

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 are molybdenum ores mined in the Malartic district of western 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 1968 totalled 639,866 pounds compared with 668,476 pounds in 1967.

In 1967, world production of bismuth, according to an estimate prepared by the United States Bureau of Mines, was 7.0 million pounds. Peru was again the leading producer with output of 1.7 million pounds, mainly from the mines of Cerro de Pasco Corporation. Other substantial producers in declining order of output were Japan, Mexico, Bolivia and Mainland China. The United States, although a producer, does not publish its production statistics.

The supply-demand situation for bismuth was well balanced in 1968. Although prices remained steady in the United States, a firming trend developed in Europe toward the end of 1968. Japanese sellers reportedly withdrew from the market because of increased domestic demand, and those Europeans accustomed to buying Japanese metal were obliged to pay premium prices on the open market. In June 1965, the price of bismuth in the United States reached an all-time high of $4 a pound at which it remained until the end of December 1968.

The United States is the non-communist world's largest consumer of bismuth and a substantial part of its requirements is imported from Peru, Mexico, Canada and Japan. Authorized sales of bismuth from the United States Government stockpile totalled 406,133 pounds in 1968. Stockpiled bismuth at the end of 1968 amounted to 3,406,182 pounds. The stockpile objective, for conventional war requirements, remained at 2,400,000 pounds, leaving a surplus of 1,006,182 pounds.

DOMESTIC SOURCES

BRITISH COLUMBIA

Cominco Ltd. remained the only producer of bismuth metal in British Columbia, deriving most of its output from lead concentrate 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

Bismuth production figures for Molybdenite Corporation of Canada Limited during its fiscal year ended September 30, 1968 are not available since its mill was destroyed by fire in October 1967 and the company's new 1,200-ton-a-day concentrator did not begin start-up operations until December 1968. In its

*Mineral Resources Branch.

TABLE 1

Bismuth – Canadian Production and Consumption, 1967-68

	1967		1968P	
	Pounds	$	Pounds	$
Production all forms*				
Quebec	521,697	1,327,661	429,240	1,532,561
British Columbia	142,507	572,878	194,626	838,838
Ontario	4,272	18,412	–	–
New Brunswick	–	–	16,000	64,000
Total	668,476	1,918,951	639,866	2,435,399
Consumption, refined metal				
Fusible alloys and solders	34,604		40,297	
Other uses**	13,290		19,049	
Total	47,894		59,346	

Source: Dominion Bureau of Statistics.
*Refined bismuth metal from Canadian ores plus recoverable bismuth content of bullion and concentrates exported. **Includes bismuth metal used in manufacture of pharmaceuticals and fine chemicals, other alloys and malleable iron.
PPreliminary; –Nil.

fiscal year ended September 30, 1967 the company treated 261,593 short tons of ore and recovered 127,590 pounds of bismuth in impure metal ingots from its operations in Lacorne Township 12 miles northeast of Malartic. Three principal steps are involved in the process. A bulk concentrate containing about 8 per cent bismuth is produced by flotation. By leaching this concentrate 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.

Operations continued at the molybdenum-bismuth property of Cadillac Moly Mines Limited (formerly Anglo-American Molybdenite Mining Corporation) in the Township of Preissac, 16 miles northwest of Malartic. Production statistics have not been reported for 1968, but in 1967 the company processed over 400,000 tons of ore and at the end of that year its ore reserves were estimated at 825,000 tons averaging 0.25 per cent molybdenite (MoS_2) and 0.04 per cent bismuth. Mining and milling operations also continued at Preissac Molybdenite Mines Limited, in which Molybdenite Corporation of Canada Limited holds a substantial interest. This molybdenum-bismuth property is in Preissac Township about 17 miles northwest of Malartic; the company produces metallic bismuth of about 95 per cent purity.

Gaspé Copper Mines, Limited recovered 19,635 pounds of byproduct bismuth in impure metal ingots in 1968 from the treatment of flue dust derived from copper-smelting operations at Murdochville, on the Gaspé Peninsula.

TABLE 2

Bismuth – Canadian Production, Exports and Consumption, 1959-68
(pounds)

	Production (all forms)[1]	Exports[2]	Consumption[3]
1959	334,736	300,000	39,700
1960	423,827	286,000	44,700
1961	478,118	389,500	42,600
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
1968P	639,866	..	59,300

Source: Dominion Bureau of Statistics.
[1]Refined bismuth metal from Canadian ores plus recoverable bismuth content of bullion and concentrates exported. [2]Refined and semi-refined bismuth metal. [3]Refined bismuth metal reported by consumers.
PPreliminary; . .Not available.

TABLE 3

Estimated World Production of Bismuth, 1967p
(pounds)

Peru	1,698,000e
Japan (metal)	1,213,000e
Mexico	1,168,000e
Bolivia (exports)	1,102,300e
Canada (metal)	668,476
Mainland China (in ore)	660,000e
Yugoslavia (metal)	236,928
Total	6,746,704*

Source: Minerals Yearbook 1967, United States Department of the Interior, and for Canada, Dominion Bureau of Statistics.

*Total is of listed figures only; it excludes United States production, which is not available for publication, as well as that of some other smaller producing countries.
pPreliminary; eEstimated.

TABLE 4

United States Consumption of Bismuth, by Principal Uses
(pounds)

	1967	1968p
Fusible alloys	826,528	658,490
Other alloys	456,246	425,405
Pharmaceuticals*	1,211,663	1,178,508
Experimental uses	9,433	6,000e
Other uses	9,782	8,000e
Total	2,513,652	2,276,403

Source: Mineral Industry Surveys, United States Department of the Interior, Bureau of Mines, Bismuth Metal in fourth quarter of 1968.

*Includes industrial and laboratory chemicals.
pPreliminary; eEstimated.

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. 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 accounts for substantial quantities of these alloys. Bismuth's use as a catalyst in the production of acrylic plastics declined again in the United States in 1968 because of the near completion of new plant facilities and its partial replacement by a less expensive substitute.

Type metal contains bismuth because the latter expands on solidification and imparts expansion to its alloys. Bismuth 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

Canadian and United States prices of bismuth did not change during 1968. The Canadian price, quoted by Cominco Ltd., for bars 99.99+ per cent pure was $4.25 a pound in lots of one ton or more and $4.50 a pound in lots of less than one ton. The United States price, as published by *Metals Week* and expressed in United States currency, was $4.00 a pound in ton lots, delivered.

TARIFFS*

	Most Favoured Nation
CANADA	
Bismuth, metallic, in its natural state	free
UNITED STATES	
Bismuth metal, unwrought	1% ad val.
Alloys of bismuth:	
Containing by weight not less than 30 per cent of lead	free
Other	14% ad val.
Bismuth metal, wrought	14% ad val.

Sources: The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa.

Tariff Schedules of the United States Annotated (1969) TC Publication 272.

*On and after January 1, 1969.

Cadmium

ROBERT J. SHANK*

Cadmium occurs in nature predominately in the sulphide form closely associated with sphalerite, the most common ore of zinc. Because cadmium resembles zinc chemically, it follows zinc through the various metallurgical processes used to concentrate sphalerite and produce zinc metal. Cadmium is separated from the zinc during the process either chemically or by distillation. Canadian zinc ores contain from 0.001 per cent to 0.067 per cent of recoverable cadmium but 70 per cent of the zinc deposits presently being mined have ores that contain 0.02 per cent cadmium or less.

In 1968, Canadian output of refined metal plus the recoverable cadmium content of exported ores amounted to 5,437,917 pounds valued at $15,287,811. Corresponding figures for 1967 were 4,836,317 pounds with a value of $13,541,688. This increase of 600,000 pounds of cadmium, a 12 per cent rise, was mainly accounted for by increased output from Ecstall Mining Limited, a sudsidiary of Texas Gulf Sulphur Company, at its Timmins, Ontario, operation, and by higher cadmium production from various mines in British Columbia.

Metallic cadmium is recovered as a byproduct at the electrolytic zinc plants at 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. East Coast Smelting and Chemical Company Limited recovers a zinc-cadmium sponge at its Belledune, New Brunswick, lead-zinc smelter, and ships this sponge to Canadian Electrolytic Zinc for refining. In 1968, metallic cadmium produced in Canada totalled 2,077,554 pounds.

*Mineral Resources Branch.

The United States continued to be the world's leader in cadmium production in 1968 with output amounting to 5,327 short tons. The USSR, Japan and Canada follow in that order, as shown in Table 3.

Canadian industry consumes less than eight per cent of domestic production, the remainder being exported to nine countries in 1968. These exports of refined cadmium metal totalled 1,802,780 pounds, of which 62 per cent went to Britain and 37 per cent to the United States.

On a world basis, cadmium demand and supply were in virtual balance during the first half of 1968 even though a large part of the United States producer industry was affected by strikes. Japanese and Russian shipments of the metal to Europe started to ease off about mid-year, causing European importers to look to the United States for their supplies. Increased production in the United States following the end of the base-metal industry's strikes, and sales of cadmium from the General Services Administration (GSA) stockpile, helped provide metal for export to Europe.

DOMESTIC PRODUCTION

Because cadmium is a minor constituent of zinc ores, statistics of its occurrence are incomplete. In Table 4, pertinent information of those mines that report their cadmium production is listed. Other mines, that have cadmium in their zinc concentrates but do not report this as production, are discussed below.

TABLE 1

Cadmium – Production, Exports and Consumption 1967-68

	1967		1968p	
	Pounds	$	Pounds	$
Production				
All forms[1]				
Ontario	2,024,006	5,667,217	2,492,730	6,976,855
British Columbia	991,316	2,775,685	1,274,719	3,632,949
Northwest Territories	911,400	2,551,920	900,000	2,565,000
Quebec	411,656	1,152,637	337,027	891,952
Manitoba	204,766	573,345	213,251	607,765
Saskatchewan	134,332	376,129	98,190	279,840
New Brunswick	51,600	144,480	71,250	188,812
Yukon	94,999	265,997	50,750	144,638
Newfoundland	12,242	34,278	–	–
Total	4,836,317	13,541,688	5,437,917	15,287,811
Refined[2]	2,057,566		2,077,554	
Exports				
Cadmium metal				
Britain	798,529	2,088,000	1,111,116	2,914,000
United States	780,020	1,967,000	661,666	1,559,000
Belgium and Luxembourg	–	–	15,308	43,000
Czechoslovakia	33,600	91,000	11,200	30,000
Other countries	64,527	156,000	3,490	10,000
Total	1,676,676	4,302,000	1,802,780	4,556,000
Consumption (cadmium metal)[3]				
Plating	121,040		. .	
Solders	13,027		. .	
Other products[4]	20,694		. .	
Total	154,761		. .	

Source: Dominion Bureau of Statistics.

[1] Production of refined cadmium from domestic ores plus recoverable cadmium content of ores and concentrates exported; [2] Refined cadmium, all forms, including cadmium in sponge; [3] As reported by consumers; [4] Mainly chemicals, pigments and alloys other than solder.

p Preliminary; – Nil; . . Not available.

NEWFOUNDLAND

Exploration work continued on the cadmium-bearing, iron-free, sphalerite deposit of Newfoundland Zinc Mines Limited at Daniel's Harbour. The deposit was reported to contain 5.4 million tons that averaged 7.7 per cent zinc and commercial amounts of cadmium.

NEW BRUNSWICK

Brunswick Mining and Smelting Corporation Limited operates two mines, and, through a wholly-owned subsidiary, East Coast Smelting and Chemical Company Limited, an Imperial Smelting Furnace near Bathurst. The smelter treats concentrates from Brunswick's mines only and produces cadmium in the form of a zinc-cadmium sponge. Concentrates not smelted locally are exported to Belgium, Germany and Italy.

QUEBEC

Manitou-Barvue Mines Limited at Val d'Or, has the highest grade of cadmium of the zinc-copper mines of northwestern Quebec, about 0.3 per cent in the zinc concentrates. Concentrates from Mattagami Lake Mines Limited, Mines de Poirier inc., New Hosco Mines Limited, Normetal Mines Limited, Orchan Mines Limited, and Quemont Mines Limited contain from 0.06 to 0.16 per cent cadmium. Output from New Calumet Mines Limited, which ceased production in October, 1968, was of comparable grade. Canadian Electrolytic Zinc Limited recovers cadmium both as refined metal and as an impure sponge. The sponge is suitable for use as a paint pigment. Output of cadmium in 1968 by Canadian Electrolytic Zinc amounted to 508,260 pounds.

ONTARIO

Ecstall Mining Limited, at Timmins, is the largest producer of cadmium in Canada. The other Timmins-area operations, Canadian Jamieson Mines Limited and Kam-Kotia Mines Limited, have lesser amounts of cadmium in their zinc concentrates. In the Manitouwadge area the Geco mine of Noranda Mines Limited produces an important amount of cadmium, and lesser amounts come from Willecho Mines Limited and Willroy Mines Limited.

MANITOBA AND SASKATCHEWAN

Virtually all 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. This plant produced 330,900 pounds of cadmium in 1968, down six per cent from 1967.

BRITISH COLUMBIA

Metallic cadmium, amounting to 701 tons, 44 tons more than in 1967, was recovered at the metallurgical works of Cominco Ltd. at Trail. Cominco treats ores and concentrates from its own Sullivan and Bluebell mines, from its subsidiary Pine Point Mines Limited, and, on a custom basis, from various mining operations in British Columbia. In addition to the mines listed in Table 4, Canadian Exploration, Limited produces zinc concentrates with an above average cadmium content.

YUKON TERRITORY

United Keno Hill Mines Limited continued to mine the highest grade of ore in terms of cadmium content in Canada and to turn out the highest grade of concentrate. Operations have been on a reduced scale for the past two years with the mill operating one shift a day. Exploration work on the property of Venus Mines Ltd. has indicated a small tonnage of lead-zinc-silver ore that averages 0.093 per cent cadmium, some 40 per cent higher than the recoverable content of the ore at United Keno.

TABLE 2

Cadmium – Production, Exports and Consumption, 1959-68
(pounds)

	Production		Exports	
	All Forms[1]	Refined[2]	Cadmium Metal	Consumption[3]
1959	2,160,363	2,528,000	1,979,638	226,000
1960	2,357,497	2,238,000	2,056,333	190,000
1961	1,357,874	2,234,000	1,901,962	171,000
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	2,220,000	1,623,679	178,000
1965	1,755,925	948,000	1,634,645	172,000
1966	3,236,862	1,705,000	2,012,323	171,000
1967	4,836,317	2,057,566	1,676,676	155,000
1968p	5,437,917	2,077,554	1,802,780	. .

Source: Dominion Bureau of Statistics.

[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 some cadmium in sponge; [3] As reported by consumers.

p Preliminary; . . Not available.

NORTHWEST TERRITORIES

Ores and concentrates shipped from Pine Point Mines Limited contained an estimated 1¼ million pounds of cadmium. Mining of high-grade direct-shipping ore ended in December 1968 and this output is expected to be replaced by production from the Pyramid mine and mill.

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 less active metals 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 electro-deposited with less electric current per unit of area covered. Because it is more costly and much less plentiful than zinc, it is not as widely used. Improvements 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 of 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 five to ten 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 one 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 fin-stock, replacing the low-silver copper formerly used exclusively.

TABLE 3

World Production of Cadmium
(short tons)

	1967	1968p
United States	4,350	5,327
USSR	2,205e	2,205e
Japan	2,093	2,028e
Canada	765	812
Belgium	716e	705e
Australia	578	503
Poland	550e	550e
France	549	623e
Republic of the Congo (Kinshasa)	445e	450
Federal Republic of Germany	440	377
Other	1,243	1,253
Total	13,934	14,833

Source: World Bureau of Metal Statistics.

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.

p Preliminary; e Estimated.

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, 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 small portable items such as battery-operated shavers, toothbrushes, drills and hand saws.

PRICES

The Canadian price of cadmium in sticks, bars, and balls, 99.98 per cent, in 5,000-pound minimum lots, as reported in the *Northern Miner* was $2.85 a pound throughout 1968. In lots under 5,000 pounds, the price was $3.05 a pound.

The United States price, according to *Metals Week*, was $2.65 a pound for one ton lots and $2.70 a pound for deliveries under one ton. Prices set by the General Services Administration for releases of cadmium from the Government stockpile were $2.53 a pound for ton lots and $2.58 a pound for less than one ton lots.

TABLE 4

Companies Reporting Cadmium Production – 1968 and (1967)

COMPANY LOCATION	MILL CAPACITY (tons ore/day)	GRADE OF ZINC CONCENTRATE				ZINC CONCEN-TRATE PRODUCED (tons)	CONTAINED CADMIUM in ZINC CONC. (pounds)	REMARKS
		Cadmium (%)	Zinc (%)	Lead (%)	Silver (oz/ton)			
NEWFOUNDLAND								
American Smelting and Refining Company, Buchans Unit, Buchans	1,250 (1,250)	0.22 (0.22)	57.78 (57.45)	3.85 (3.87)	4.48 (4.40)	68,550 (72,235)	304,000 (318,000)	Normal operations.
NEW BRUNSWICK								
Heath Steele Mines Limited, Newcastle	1,600 (1,500)	. . (0.10)	49.47 (49.38)	. . . .	. . . .	29,294 (47,994)	. . (95,988)	Milling of Wedge ore ceased in May. Mill overhauled, capacity increased. Production of zinc concentrates temporarily suspended in October. Mill capacity to be increased to 3,000 tons a day in 1969.
Nigadoo River Mines Limited, Robertville	1,000 (1,000)	0.70 (0.70)	45.86 (42.60)	2.12 (3.55)	4.91 (5.37)	9,841 (482)	141,211 (6,750)	Milling started November, 1967.
QUEBEC								
Cupra Mines Ltd., Stratford Centre	1,500 (1,500)	0.28 (0.30)	56.42 (55.05)	. . (1.57)	. . (1.88)	11,165 (11,558)	64,619 (69,348)	Exploring new parallel zone. Developing D'Estrie property from Cupra workings.
Lake Dufault Mines, Limited, Noranda	1,300 (1,300)	. . (0.14)	51.50 (51.85)	– –	– –	24,538 (66,311)	. . (187,141)	Sinking new shaft on D-134 ore zone, 3½ miles south of main shaft. Mining lower-grade ore. Mill being automated.
Solbec Copper Mines, Ltd., Stratford Centre	– –	0.28 (0.28)	54.11 (53.10)	. . (0.48)	. . (2.60)	18,133 (5,384)	101,000 (30,250)	Routine mining of remaining ore reserves. Ore treated in Cupra mill.

TABLE 4 (Cont'd)

COMPANY LOCATION	MILL CAPACITY (tons ore/day)	GRADE OF ZINC CONCENTRATE Cadmium (%)	Zinc (%)	Lead (%)	Silver (oz/ton)	ZINC CONCEN-TRATE PRODUCED (tons)	CONTAINED CADMIUM in ZINC CONC. (pounds)	REMARKS
ONTARIO								
Ecstall Mining Limited, Timmins	9,000 (9,000)	0.27 (0.30)	52.24 (52.00)	– . .	3.96 (5.00)	562,493 (432,000)	3,091,444 (2,600,000)	Routine open-pit mining. Planning for underground operations.
Zenmac Metal Mines Limited, Schreiber	200 (165)	0.13 (0.12)	52.90 (52.28)	– –	– –	7,488 (16,783)	36,321 (40,819)	Exploring new zone southeast of shaft.
MANITOBA AND SASKATCHEWAN								
Hudson Bay Mining and Smelting Co., Limited, Flin Flon	6,000 (6,000)	. . . .	47.60 (46.63)	0.30 (0.40)	1.00 (1.15)	131,300 (106,436)	330,900 (352,042)	Production commenced at Osborne Lake mine. Shafts deepened at Anderson and Flexar mines. Shaft sinking at Dickstone mine.
Western Nuclear Mines, Ltd., Hanson Lake	350 (350)	. . (0.07)	50.52 (50.20)	– –	2.85 –	9,097 (4,014)	. . (51,936)	Operations suspended January to June because strikes in U.S. stopped marketing of concentrates.
BRITISH COLUMBIA								
Anaconda Britannia Mines Ltd., Britannia Beach	3,000 (3,000)	. . (0.26)	. . (54.01)	– –	. . (0.87)	. . (2,181)	. . (11,423)	Developing new O4C ore zone below 4100 level.
Cominco Ltd., Sullivan Mine, Kimberley	10,000 (10,000)	0.12 (0.12)	50.05 (49.50)	5.93 (6.40)	4.48 (5.50)	131,829 (128,610)	316,390 (308,664)	Normal development.
Mastodon-Highland Bell Mines Limited, Beaverdell	115 (120)	0.37 (0.48)	34.53 (43.60)	2.18 (1.91)	55.19 (36.37)	291 (494)	2,142 (4,778)	Employees on strike Sept. 19 to Oct. 3.
Reeves MacDonald Mines Limited, Remac	1,200 (1,200)	0.36 (0.38)	53.11 (53.14)	1.92 (2.01)	0.88 (1.17)	19,127 (20,924)	138,966 (159,460)	Starting internal shaft at Annex mine.

Western Mines Limited, Buttle Lake, V.I.	1,000 (750)	0.25 (0.24)	54.98 (54.98)	. . (2.47)	4.36 (4.07)	. . (34,595)	226,220 (170,537)	Developing Paramount and Lynx properties.
YUKON TERRITORIES								
United Keno Hill Mines Limited, Elsa	500 (500)	. . (0.80)	. . (55.00)	. . (1.50)	. . (20.00)	4,902 (8,872)	24,042 (128,269)	Producing from Hector-Calumet mine. Sinking shaft on Husky zone. Reopening Sadie-Ladue workings. Mill rate reduced to 50,000 tons a year.

– Nil; . . Not available.

TARIFFS

Revisions to Cadmium Tariffs Negotiated at the Kennedy Round, GATT, 1967

ITEM	Unit	Before 1968*	1968*	1969*	1970*	1971*	1972*
CANADA* **							
Cadmium in metal, lumps, powder ingots or blocks	%	15	13	11	9	7	5
UNITED STATES							
Cadmium in ores and concentrates		Free	Free	Free	Free	Free	Free
Cadmium metal, unwrought, waste and scrap**	¢/lb	3.75	3.0	2.0	1.0	Free	Free
Cadmium metal, wrought, and cadmium alloys unwrought	%	18	16	14	12.5	10.5	9
Cadmium flue dust		Free	Free	Free	Free	Free	Free

Sources: The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa.
Tariff Schedules of the United States Annotated (1969) TC Publication 272.
*As of January 1.
**Duty on waste and scrap suspended.
***Most Favoured Nation tariff.

Calcium

W. H. JACKSON*

World production of calcium metal is not known with any certainty but an estimate of under 1000 tons is in the right order of magnitude. There are three sources in the non-communist world. The Canadian producer Dominion Magnesium Limited is the leading supplier in international trade. Charles Pfizer and Co. Inc., Minerals, Pigments and Metals Division in the United States and Planet-Wattohm S.A., a subsidiary of Compagnie de Mokta, in France, are the other producers. All use thermal reduction methods and capacity is adequate to meet any foreseeable industrial requirement.

DOMESTIC INDUSTRY

Dominion Magnesium Limited produces four grades of calcium (Domal-Grade 1, Grade 2, Grade 4 and Grade 5) at the Haley smelter in Ontario in addition to its main product, magnesium, which is covered in another review in this series. To produce Grade 4 calcium, purchased high-purity powdered lime (CaO) of 200 mesh and commercial-purity aluminum of 20 mesh are briquetted and then charged into horizontal retorts made of chrome-nickel-iron alloy. Under vacuum and at temperatures of about 1,170°C the aluminum reduces the lime. The water-cooled head sections of the retorts project through the furnace wall and calcium vapour condenses as crystalline rings in a temperature range of 680°C to 740°C. Higher purities are obtained by subsequent refining operations.

Grade 1 is nominally 99.9 per cent pure. Minor impurities are similar to those of Grade 2 which contains 99.5 per cent calcium or 99.9 calcium plus magnesium. In both grades the impurity content is low, the maximum being 0.004 per cent manganese, 0.005 iron, 0.025 nitrogen and 0.010 aluminum. Such elements as nickel, lithium, boron, sodium and cadmium are extremely minor impurities. Grade 4 contains 98 to 99 per cent calcium, 0.5 to 1.5 per cent magnesium, 1 per cent nitrogen maximum and 0.35 per cent aluminum maximum. Grade 5 is nominally 95 per cent calcium.

Dominion Magnesium reported calcium shipments in 1968 were 234 tons compared with 272 tons in 1967. Canadian consumption is in the order of 75 tons and most of the output was despatched to markets in United States, Britain, West Germany and Japan. In addition to calcium, minor quantities of other metals were produced in 1968 at Haley as follows: thorium (1,048 lb), mainly for magnesium alloys; titanium (4,105 lb), for nickel alloys and fuses; zirconium-magnesium master alloys (9,689 lb); barium (1,789 lb), a getter in vacuum tubes; and strontium (82 lb) for laboratory use.

USES

Small quantities of Grade 1 are used for experimental or pilot plant work or where pure metal is needed for chemicals or isotope separation. Grade 2 is in demand as a reducing agent for thorium and zirconium, and can be used in the reduction of other metals such as beryllium and uranium. Grade 4 is adequate for the manufacture of calcium hydride, a portable source of hydrogen for meteorological balloons and rescue devices. The main use of Grade 5 is in the separation of bismuth from lead. Other applica-

*Mineral Resources Branch.

TABLE 1

Canadian Calcium Production and Exports, 1967-68

	1967		1968P	
	Pounds	$	Pounds	$
Production (metal)*	543,692	535,509	445,612	421,756
Exports (metal)				
United States	414,100	359,000	323,600	303,000
West Germany	35,400	40,000	17,600	20,000
Britain	12,000	21,000	8,200	13,000
Japan	6,600	6,000	4,000	4,000
Other countries	44,900	58,000	300	1,000
Total	513,000	484,000	353,700	341,000

Source: Dominion Bureau of Statistics.

*Smelter use and shipments.

PPreliminary.

TABLE 2

Canadian Calcium Production and Exports, 1959-68

	Production* (pounds)	Exports (pounds)
1959	67,429	65,100e
1960	134,801	74,800e
1961	99,355	110,700
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
1968P	445,612	353,700

Source: Dominion Bureau of Statistics.

*Production from 1959 to 1960 inclusive, shipments from 1961.

PPreliminary; eEstimated.

tions include deoxidation and sulphur removal in maraging, and other high quality steels, grain refining in aluminum-silicon alloys, and for selenium recovery.

PRICES

The Canadian price in 1968 quoted by Dominion Magnesium Limited, f.o.b. Haley, Ontario ranged from 85 cents a pound for the Grade 4 to $3.50 a pound for the Grade 1.

TARIFFS

Most Favoured Nation Tariff
(per cent ad valorem)

	Before 1968	1968*	1969*	1970*	1971*	1972*
CANADA						
Calcium metal	15	13	11	9	7	5
Calcium alloys	20	19.5	19	18.5	18	17.5
UNITED STATES						
Calcium metal, unwrought	15	13	12	10	9	7.5
Calcium metal, wrought	18	16	14	12.5	10.5	9

*Effective date Jan. 1.

Source: Canada, The Customs Tariff and Amendments, Dept. of National Revenue; Tariff Schedules of United States Annotated (1968).

Cement

N.G. ZOLDNERS*

Construction activity in Canada during 1968 showed a slight improvement in its continuous upward trend, reaching a total of $12.2 billion, which is a 5.6 per cent increase over the 1967 value of $11.6 billion.

This general trend in construction had a beneficial influence on the entire building materials industry, particularly in areas where construction activity is larger. This reflected also in the total volume of Canada's cement production, which increased in 1968 to about 8.3 million short tons**, indicating an increase of about 3.6 per cent over the 1967 production, with its value of $156.5 million or 3.3 per cent. Of the total mineral production, cement ranks eighth among Canada's leading minerals.

With the addition of a new cement plant and a major expansion of an existing plant, both in Ontario, Canada's annual rated capacity increased more than 9 per cent over that in 1967, reaching a total capacity of 82.2 million barrels by the end of 1968. An increase of production capacity of the cement industry at a time of only moderate increase in the construction volume resulted naturally in the lower overall operating efficiency of cement plants. The production rate of 1968 was down to an estimated 57 per cent of total plant capacity as compared with 61 per cent for 1967.

Major expansion of an existing cement plant in Quebec, scheduled for completion by the end of 1969, and a new plant in British Columbia to start operation in March, 1970, will add 1.2 million barrels each, thus increasing Canada's total annual rated capacity to about 84.6 million barrels.

PRODUCTION

Canada produces different types of portland cement, masonry cement, concrete-products, and oil-well cements, as well as white cement ground from imported clinker. Most of the production is normal portland cement, although other modified types of portland cement have been produced in increasing amounts in recent years. In 1968, of the total cement produced, about 96 per cent was portland and practically all the rest was masonry cement. A possibility exists that white cement will be manufactured soon in Canada.

The total amount of cement shipped from all of Canada's plants during 1968 was 8,279,152 short tons, valued at $156,541,049 (Table 1). Of this volume 67 per cent was produced in the Provinces of Ontario and Quebec where 13 of the 23 operating cement plants in Canada are located. No cement is produced in Prince Edward Island, the Yukon or the Northwest Territories.

Table 2 indicates that though Canada's total cement production apparently is again on the increase, in 1968 it was below the volume produced in 1965. Three provinces - Alberta, British Columbia and New Brunswick produced less cement in 1968 than in 1967.

In 1968 cement clinker was produced in 23 plants operating 56 rotary kilns. Sixteen plants employed the wet process and seven used the dry method of cement manufacture. One plant in Ontario has the facilities for both wet and dry processes. The approximate capacities of Canada's cement plants at the end of 1968 are shown in Table 3. The location of these plants is shown in the accompanying map. In addition, Canada Cement Company, Limited, operated two clinker grinding plants - one in Edmonton and one in Saskatoon, each 1,900,000 barrels in capacity. Medusa Products Company of Canada, Limited, grinds imported clinker at Paris, Ontario, for the production of white cement. The Canadian cement industry now operates 31 cement storage and distribution terminals, established in strategic locations.

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*Mineral Processing Division, Mines Branch,
**1 short ton = 2,000 lb = 5.7 barrel (imperial);
1 barrel = 4 bags = 350 lb; 1 USA barrel = 376 lb.

TABLE 1

Canada – Cement – Production and Trade, 1967-68

	1967		1968p	
	Short Tons	$	Short Tons	$
Production[1]				
Ontario	2,894,483	47,597,495	3,187,000	57,555,500
Quebec	2,284,323	34,997,061	2,400,961	41,073,140
Alberta	885,463	17,362,618	799,800	16,193,000
British Columbia	709,977	16,950,591	677,203	15,027,424
Manitoba	415,059	9,033,093	461,533	9,895,000
Saskatchewan	280,435	7,790,020	294,655	8,825,000
Nova Scotia	212,927	3,770,834	223,000	4,040,000
New Brunswick	230,070	3,904,288	140,000	2,520,000
Newfoundland	82,217	1,744,284	95,000	1,411,985
Total	7,994,954	143,150,284	8,279,152	156,541,049
By type				
Portland	7,732,953	137,861,788	7,989,382e	..
Masonry[2]	262,001	5,288,496	289,770e	..
Total	7,994,954	143,150,284	8,279,152	156,541,049
Exports				
Portland cement				
United States	327,996	5,201,000	365,897	6,073,000
Other countries	22	2,000	609	14,000
Total	328,018	5,203,000	366,506	6,087,000
Cement and concrete basic products				
United States		233,000		492,000
Other countries		57,000		90,000
Total		290,000		582,000
Imports				
Portland cement, white				
United States	12,072	559,000	16,336	705,000
Belgium and Luxembourg	2,666	81,000	6,784	209,000
Japan	4,644	128,000	4,192	119,000
Denmark	1,654	51,000	1,511	45,000
Britain	1,658	44,000	1,149	29,000
West Germany	88	3,000	153	7,000
Other countries	109	4,000	–	–
Total	22,891	870,000	30,125	1,114,000
Cement, n.e.s.[3]				
Britain	15,161	412,000	13,321	474,000
United States	4,044	331,000	5,750	340,000
West Germany	2,022	111,000	1,919	101,000
France	–	–	385	10,000
Total	21,227	854,000	21,375	925,000
Total cement imports	44,118	1,724,000	51,500	2,039,000

TABLE 1 (cont'd)

	1967		1968p	
	Short Tons	$	Short Tons	$
Imports (cont'd)				
Refractory cement and mortars				
United States		1,300,000		1,511,000
Ireland		402,000		273,000
Other countries		9,000		53,000
Total		1,711,000		1,837,000
Cement and concrete basic products, n.e.s.				
United States		149,000		146,000
Britain		12,000		9,000
Other countries		19,000		2,000
Total		180,000		157,000
Cement Clinker				
United States	14,969	386,000	13,773	356,000

Source: Dominion Bureau of Statistics.
[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; eEstimated.

TABLE 2

Canada, Cement – Production, Trade and Consumption, 1959-68
(short tons)

	Production[1]	Exports[2]	Imports[2]	Apparent Consumption[3]
1959	6,284,486	303,126	29,256	6,010,616
1960	5,787,225	181,117	22,478	5,628,586
1961	6,205,948	249,377	29,217	5,985,788
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
1968p	8,279,152	366,506	51,500	7,964,146

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

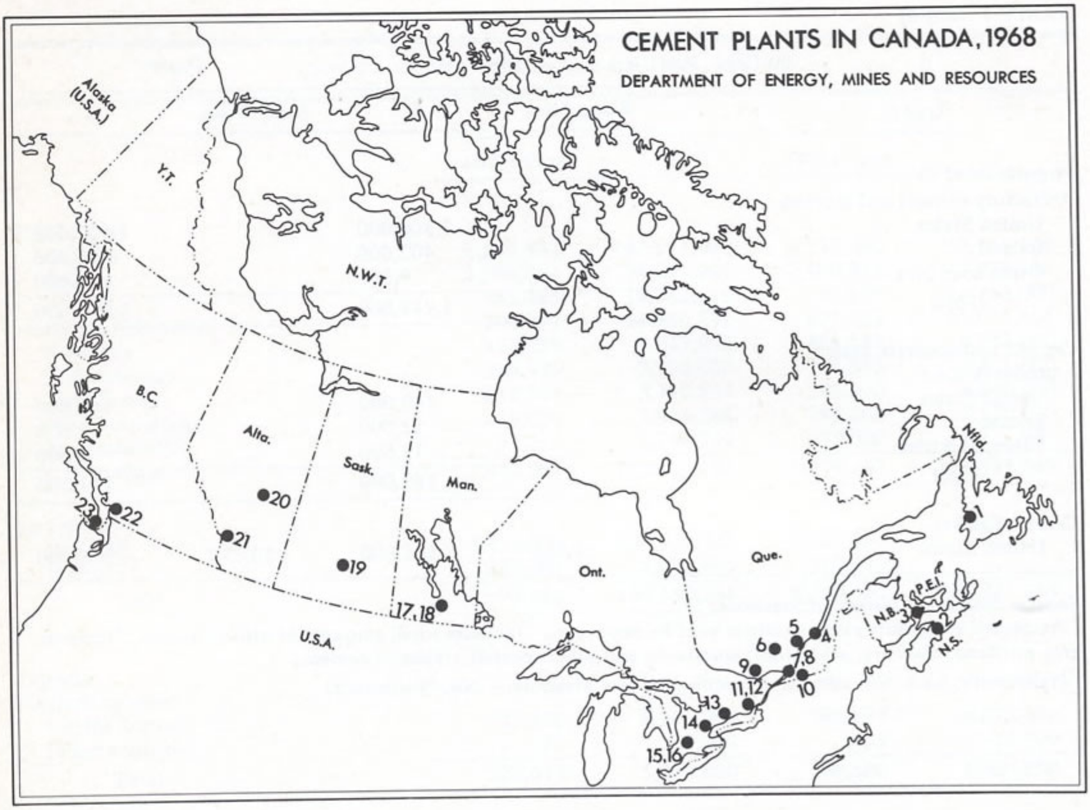


Table 4 summarizes changes in the production capacity of Canada's cement industry since 1958. In the last 10 years the total rated production capacity has nearly doubled. During this period the average plant capacity increased by 50 per cent and kiln capacity by 40 per cent, or 3.55 and 1.43 million barrels per annum, respectively, indicating a trend towards larger plants and higher productivity per kiln. In the United States the average capacity of a cement plant in 1967 was 2.69 million U.S. barrels per annum.

In 1967*, the raw materials used in the manufacture of cement included 11,058,249 tons of limestone, 1,146,172 tons of clay, 443,975 tons of shale, 372,128 tons of gypsum, 293,189 tons of high-silica sand and 71,271 tons of iron oxide, generally produced from iron pyrites by the chemical industry.

Because cement is a relatively low-priced commodity, being sold for less than one cent per pound, the transportation of raw materials is usually one of the controlling factors affecting the total production cost. Lack of limestone deposits near cement plants in Manitoba, Saskatchewan and Alberta makes it necessary to transport raw materials long distances. Inland's cement plant in Regina hauls all its limestone 275 miles from a deposit in Manitoba and at its Edmonton plant about 200 miles from Cadomin quarry. Suitable raw material deposits within reasonable haulage distances of cement plants are constantly sought.

Long-range planning and expansion in the cement manufacturing industry is leading to continuous overbuilding in the cement-clinker producing facilities resulting in an increased overcapacity. The average operating capacity of the Canadian cement industry, as shown in Table 4, decreased during the last 10 years from 82 per cent of the year-end annual rated capacity in 1958 to 57 per cent in 1968. These figures are somewhat confusing. They are based on clinker producing capacities of the plants. Lack of sufficient grinding equipment at some plants will bring the operating capacity of the industry down. Some old capacity can only be used economically as reserve capacity, when demand reaches the peak during the time of the highest construction activities, mostly in fall months. Some experts in the cement industry are inclined to speculate that the true ratio of production to capacity in 1968 was closer to 70 per cent than the official 57 per cent figure. With an additional new

*1968 figures not available at time of writing.

TABLE 3

Approximate Cement-Plant Capacities* at End of 1968
(numbers in parentheses refer to locations on the accompanying map)

Company and Location	Barrels per Year	Short Tons per Year**
Newfoundland		
North Star Cement Limited, Corner Book (1)	900,000	158,000
Nova Scotia		
Maritime Cement Company Limited, Brookfield (2)	1,500,000	263,000
New Brunswick		
Maritime Cement Company Limited, Havelock (3)	2,000,000	351,000
Quebec		
St. Lawrence Cement Company, Villeneuve (4)	4,500,000	789,000
Ciment Quebec Inc., St. Basile (5)	2,500,000	439,000
Independent Cement Inc., Joliette (6)	2,500,000	439,000
Miron Company Ltd., St. Michel (7)	6,000,000	1,052,000
Canada Cement Company, Limited, Montreal (8)	8,000,000	1,404,000
Canada Cement Company, Limited, Hull (9)	1,200,000	211,000
Lafarge Cement Quebec Ltd., St. Constant (10)	3,000,000	525,000
Ontario		
Lake Ontario Cement Limited, Picton (11)	4,500,000	789,000
Canada Cement Company, Limited, Belleville (12)	4,400,000	772,000
St. Mary's Cement Co., Limited, Bowmanville (13)	2,400,000	421,000
St. Lawrence Cement Company, Clarkson (14)	10,260,000	1,800,000
Canada Cement Company, Limited, Woodstock (15)	3,400,000	596,000
St. Mary's Cement Co., Limited, St. Mary's (16)	4,300,000	754,000
Medusa Products Company of Canada, Limited, Paris (grinding only)		
Manitoba		
Canada Cement Company, Limited, Fort Whyte (17)	3,600,000	632,000
Inland Cement Industries Limited, Winnipeg (18)	2,000,000	351,000
Saskatchewan		
Inland Cement Industries Limited, Regina (19)	1,300,000	228,000
Canada Cement Company, Limited, Floral (grinding only – 1.9 mill. bbl)		
Alberta		
Inland Cement Industries Limited, Edmonton (20)	3,300,000	579,000
Canada Cement Company, Limited, Exshaw (21)	3,100,000	544,000
Canada Cement Company, Limited, Edmonton (grinding only – 1.9 mill. bbl)		
British Columbia		
Lafarge Cement of North America Ltd., Lulu Island (22)	3,500,000	614,000
Ocean Cement Limited, Bamberton (23)	4,000,000	702,000
Total	82,160,000	14,414,000

Source: Published data and private correspondence.
*Not including the capacities of the separate grinding plants.
**Calculated.

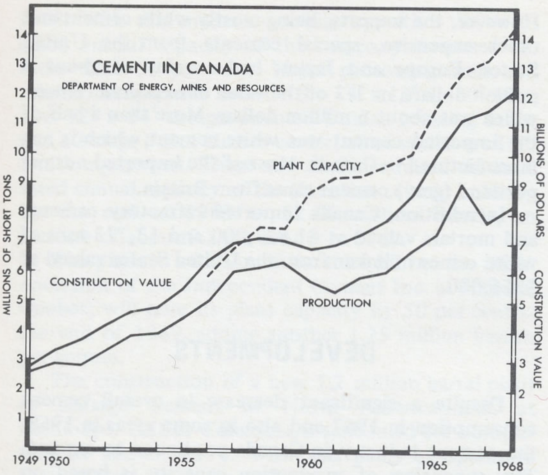
TABLE 4

Canada, Cement-Rated Production Capacity,[1] 1958-68

			Approximate Capacity[2]		Average Capacity[2]		Production	
	No. of Plants[2]	No. of Kiln[2]	Barrels per year	Short Tons per year	Per Plant (million bbl/year)	Per Kiln (million bbl/year)	Shipments (short tons)	As % of Year-End Capacity
1958	18	41	42,800,000	7,490,000	2.38	1.04	6,153,421	82
1959	18	42	42,800,000	7,490,000	2.38	1.02	6,284,486	84
1960	19	45	50,000,000	8,750,000	2.63	1.11	5,787,225	66
1961	19	45	51,800,000	9,065,000	2.73	1.15	6,205,948	68
1962	19	45	52,450,000	9,179,000	2.76	1.17	6,878,729	75
1963	19	45	54,600,000	9,556,000	2.87	1.21	7,013,662	73
1964	19	47	57,150,000	10,001,000	3.01	1.22	7,847,384	79
1965	21	50	67,220,000	11,770,000	3.20	1.34	8,427,702	72
1966	23	54	73,470,000	12,858,000	3.20	1.36	8,930,552	69
1967	22	56	75,270,000	13,173,000	3.42	1.34	7,994,954	61
1968	23	56	82,160,000	14,414,000	3.55	1.43	8,279,152P	57
1969[3]	23	57	83,360,000					
1970[3]	24	58	84,560,000					

[1] Clinker-processing plants. [2] Year-end. [3] Scheduled to date.

P Preliminary.



plant under construction in British Columbia and an addition of the third kiln in a cement plant in Quebec, the production rate could improve in 1969 only if cement consumption increases considerably and the out-dated and idle clinker producing facilities in some of the older cement plants are not counted in the producing capacity.

The total production capacity and the actual cement production figures are illustrated in the accompanying graph "Cement in Canada" which shows also Canada's total constuction values.

WORLD PRODUCTION

For many years the United States of America was the world's leading cement producer, but since 1965 the lead has been taken over by the USSR. The production increase in per cent during the 10-year period ending 1967 is shown in Table 5. Canada's production during this period increased by 30 per cent to 7.9 million tons, representing 13th place among the other countries. Particularly large increases in cement output during the 10-year period were recorded by the USSR (194 per cent) and Japan (183 per cent) indicating intensive construction activities in these countries. In the trend toward larger plants, USSR is leading with an average capacity of about 900,000 tons per plant as compared with the Canadian average of 600,000 tons and the United States average of 506,000 tons per plant in 1967.

The three largest cement producing countries, USSR, United States and Japan accounted for about 40 per cent of the total world cement production in 1967.

The development of the cement industry in a country is best reflected by the cement production per capita, as shown in Table 6. Canada, with a production of 782 pounds of cement per capita ranks ninth in the world. Table 6 indicates also that largest per-capita production increase during the last 10 years has been shown by the USSR - 191 per cent, followed by Japan - 181 per cent and Spain - 161 per cent.

TABLE 5

World Production of Cement
(thousand short tons)

Country,	1957	1967	Production Increase %
USSR	31,852	93,475	194
United States	58,986	72,539	23
Japan	16,728	47,391	183
West Germany	21,119	34,731	164
France	13,899	27,117	95
Italy	13,174	28,960	120
Britain	13,400	19,375	45
Spain	5,474	14,439	164
India	6,273	12,897	106
Poland	4,956	12,277	148
China	7,562	8,817	17
East Germany	3,814	7,923	108
Canada	6,049	7,892	30
Czechoslovakia	4,048	6,843	69
Other countries	64,891	134,328	107
Total	272,225	529,004	Avg. 94

Source: U.S. Bureau of Mines Minerals Yearbook, 1967.

TABLE 6

World Cement Production Per Capita

Country	Pounds of Cement 1957	1967	Increase %
1 Belgium	1,154	1,339	16
2 West Germany	721	1,203	67
3 Italy	508	1,106	117
4 France	562	1,087	93
5 Czechoslovakia	568	956	68
6 Japan	338	949	181
7 Spain	344	899	161
8 USSR	273	794	191
9 Canada	725	782	8
10 United States	686	729	6

INTERNATIONAL TRADE

A basic building material, cement is produced in more than 100 countries. Many countries are not yet self-sufficient in this commodity but more and more of them are moving fast in this direction, because the raw materials needed for cement manufacture are available in abundance all the world over.

Cement by its bulk nature is a "heavy freight" commodity and is rarely shipped economically for distances greater than 300 miles except by water transport. Only a minor proportion of world production is traded internationally. For instance, exports and imports of cement for Canada were 4.0 and 0.5 per cent in 1967 and 4.4 and 0.6 per cent, respectively, in 1968. For the United States these proportions for 1967 were 0.3 and 1.6 per cent, respectively.

Data compiled in Table 2 indicate that both export and import of cement have shown a small but continuous increase in the last six years, except in 1967, when curtailment of the domestic cement markets influenced international trade. Practically all of the Canadian cement exported is to the United States. In 1968 Canada supplied about 28 per cent of the United States cement imports, shipped mainly to New York State.

Principal exporter of Canadian cement to the United States is Lake Ontario Cement Limited, and its plant at Picton, Ontario, enjoys low-cost water shipment of cement as far as Pennsylvania. Lafarge Cement Quebec Ltd., St. Constant, Quebec is also establishing for its products a foothold in the United States by leasing a converted grain elevator on the Buffalo, N.Y., waterfront for a 500,000 bbl cement storage-distribution operation, to be ready in 1969. Inland Cement Industries Limited recently opened a $200,000 distribution plant at Port Arthur, Ontario, to move into United States cement export market from its Winnipeg plant at Tuxedo, Manitoba.

The cement imported by Canada in 1968 was, by volume, about 14 per cent of the amount exported. However, the imports, being mostly white cement and other expensive, special cements from the United States, Europe and Japan, had a value of about 2 million dollars, or 1/3 of the value of exported cement which was about 6 million dollars. More than a half of the imported cement was white cement, which is not manufactured in Canada. Most of the imported normal portland (grey) cement came from Britain.

In addition, Canada imported refractory cements and mortars valued at $1,837,000 and 13,773 tons of white cement clinker from the United States valued at $356,000.

DEVELOPMENTS

Despite a significant decrease in overall cement consumption in 1967 and also in some areas in 1968, the cement industry in Canada continued to expand. The expansion of production capacity is based on long-range planning by the industry and is expected to continue into 1970.

In 1968 a major expansion of one plant and construction work of a new plant was completed in Ontario. Addition of another kiln was planned in a Quebec plant and construction work was started on another new plant in British Columbia.

The $15 million expansion of the St. Lawrence Cement Company's plant at Clarkson, Ontario, by addition of a new dry-process preheater kiln operating in conjuction with a high-capacity Aero-fall mill boosted the original wet-process 2-kiln plant capacity to a total of 1.8 million tons yearly. This makes it Canada's largest single plant and North America's second largest.

The new St. Mary's 2.4-million barrel plant at Bowmanville went into production by the end of

TABLE 7

Cement-plant Expansion

Company and Location	Capacity Increase (million bbl/year)	Year Started	Year Scheduled for Completion	Approximate Cost ($ million)
Quebec				
Independent Cement Inc., Joliette	1.25**	1968	1969	
British Columbia				
Lafarge Cement of North America Ltd., Kamloops	1.2*	1968	1970	12

Source: Data obtained from publications and private correspondence.

*New plant. **Expansion.

1968. With this modern one-kiln operation the combined annual capacity of the company increased by more than 50 per cent. Major processing units and related components include the 14′ x 16′ x 480′ kiln, two 12′ x 34′ compartmented Unidan grinding mills, and a 2-stage Folax clinker cooler, all of which are F.L. Smith equipment. These new facilities raised the total rated annual capacity of the Canadian cement industry by the end of 1968 to 82.16 million barrels, an increase of about 9.2 per cent over 1967.

The planned addition of the third kiln to the 2-kiln operation of the Independent Cement Inc. at Joliette, Quebec, will raise its plant capacity by 50 per cent at the end of 1969, adding another 1.25 million barrels per annum.

The construction of a new 1.2 million barrel plant of Lafarge Cement of North America Ltd. at Kamloops, British Columbia, is scheduled for completion in March, 1970. With this plant in operation Lafarge Cement group with its two plants in British Columbia and one in Quebec will become the third largest producer of cement, after Canada Cement Company, Limited, and St. Lawrence Cement Comapny.

A summary of cement-plant expansions is given in Table 7.

A feasibility study is underway in British Columbia involving an entirely new process in North America in which cement is manufactured as a byproduct in a plant producing sulphuric acid from gypsum and anhydrite.

CONSUMPTION AND USE

With increased application of concrete as a building material in all types of construction, the consumption of cement in Canada has shown a continuous increase since 1960, except in 1967, when consumption dropped by more than 10 per cent from the year before. With resumption of more lively construction activity in 1968, consumption of cement rose by more than 3 per cent, which is still below the volume consumed in 1965. With an apparent consumption of cement in 1968 of about 8 million tons (see Table 2) the amount of concrete produced in Canada as a national average will be about 3 tons per capita as compared with the world average figure of 1 ton. The graph on page 7 indicates that the volume of cement production generally varies directly with the total cost of construction, though this may not be a true indication of changes in construction volume.

The cement market in various provinces depends on regional construction activity. Although market development in general depends on the overall trend in construction, cement requirements vary greatly with the type of construction and the amount of concrete being used. For example, the cost of concrete used in reinforced concrete frame buildings ranges from 20 to 30 per cent of the total cost, whereas in buildings with structural steel frame. the value of concrete accounts for only 5 to 10 per cent of the total cost of the buildings. On the other hand, each dollar spent on concrete roads, bridges and tunnels accounts for the use of almost four times as much cement as a dollar spent on residential housing. It seems that total consumption of cement is mostly affected by the volume of heavy-engineering and industrial construction.

The destination of domestic cement shipments in 1968 is shown in Table 8.

TABLE 8

Canada, Destination of Domestic Cement Shipments* 1968
(short tons)

Ontario	3,170,216
Quebec	2,003,854
Manitoba, Saskatchewan, Alberta and British Columbia	2,165,787
Newfoundland, Prince Edward Island, Nova Scotia and New Brunswick	482,099
Yukon and Northwest Territories	15,408
Canada Total	7,837,364
Exports	358,104
Total shipments	8,195,468

Source: Dominion Bureau of Statistics.
*Direct sales from producing plants.

Shipments to Ontario in 1968 increased over those in 1967 by 13 per cent, whereas shipments to Atlantic and Western provinces decreased by 10.7 and 2.5 per cent, respectively. Also, the situation in Quebec did not show any improvement over 1967, its shipments are still on decline. At the same time the volume of cement exports in 1968 showed a 12 per cent increase over 1967.

It is assumed generally that consumption of cement is related to construction activity. However, construction volume expressed in current dollars may not reflect annual changes correctly. Due to increases in workmen wages and material prices the current dollar buys less than a dollar some years ago. For comparison purposes Dominion Bureau of Statistics in its statistical work uses the "Constant 1957 dollar". When this value is being used, the construction volume for 1968 shows only 0.4 per cent increase over 1967 figure, as compared with 5.6 per cent increase in current dollars. When expressed in terms of constant 1957 dollars, construction value in 1968 decreased in the Western provinces and Quebec, showed no change for Atlantic provinces and increased for Ontario, when compared with corresponding values in 1967.

Total value of construction work performed in 1968 was divided about 60 per cent for building and 40 per cent for engineering construction. Expenditures for the latter group have a more dynamic effect on cement consumption than the former. Consequently, although the level of investment in construction influences the demand for cement, of more importance is the structural make-up of the construction program. Of all cement consumed about 22 per cent was used in residential and rural construction. The industrial and commercial construction used about 44 per cent and the governmental construction about 34 per cent of all cement sold. In the latter group are included also highways, subways, bridges, overpasses and power dams. An increasing amount of cement is being used by the mining industry in some form of back-fill in mines, rock support and other concrete work. A rough estimate of this application may account for about 0.4 million tons of cement or about 5 per cent of annual cement sales volume.

The proportion of the total consumption of cement used for ready-mixed concrete and concrete products industry has been increasing steadily during the last few years. In 1968 the ready-mixed concrete industry consumed about 55 per cent of total cement shipments in Canada producing over 14 million cubic yards of concrete, which is over 11 per cent more than in the year before. As shown in Table 9, the other concrete products manufacturers have also increased their output in 1968, thus increasing their percentage share of cement consumed, and are expected to continue to grow in importance further. Over 80 per cent of all cement delivered to concrete products and ready-mix plants was in bulk shipments.

Portland cement is the most widely used of all modern engineering construction materials, with most of it being used in concrete and different concrete products. Cement is used also in mortar, stucco, grout, soil-cement and asbestos-cement products.

With its versatility and reliability concrete used in precast and prestressed structural members almost completely frees our architectural and artistic imagination for innumerable applications.

One new and revolutionary application is the use of a ferro-cement method in the boat building trade. Discovered by Luigi Nervi about 20 years ago in Rome, Italy, this method was not widely used until recently. There are now ferro-cement boat builders in New Zealand, Australia, Britain, and quite recently the method has been adopted in Canada by boat builders in Vancouver and Richmond, British Columbia, Mill Cove, Nova Scotia, Toronto and Fort Erie, Ontario. A feasibility study of such ferro-cement boats was undertaken also by the Engineering Dept. of the University of Laval, Quebec. Under the trade name of Seacrete, ferro-cement with lightweight aggregates is being used to build sail- and power-boats, barges and floating docks.

With the availability of white cement the use of coloured concrete is on the increase. The addition of natural or synthetic pigments to cement may produce colours in a wide spectrum of shades for use in concrete products, buildings and various architectural applications. Coloured strips in pavement and white curbs provide extra safety features for ever-increasing highway traffic.

In order to secure certain captive markets for their product, most of the cement manufacturing companies acquired certain cement consuming industries such as concrete product plants, ready-mix, highway paving and construction companies. Following this trend the principals of Inland Cement Industries Limited, the Sogemines Limited are keeping up their expansion program by acquisition of BACM Industries Limited, which with its subsidiaries is a major manufacturer of concrete products in the West and dovetails nicely with Inland Cement's operations. This deal safeguards at least part of Inland's sales in Manitoba, Saskatchewan and Alberta.

TABLE 9

Canada – Production of Concrete Products

	Unit	1967	1968p
Concrete bricks	(no.)	81,925,244	88,989,498
Concrete blocks (except chimney blocks)			
Gravel	(no.)	148,718,868	159,372,311
Cinder	(no.)	4,749,995	4,211,273
Other	(no.)	43,626,918	45,771,397
Concrete drain pipe, sewer pipe, water pipe and culvert tile	(ton)	1,180,218	923,282
Concrete, ready mix	(cu. yd.)	12,473,796	14,030,936

Source: Dominion Bureau of Statistics.
pPreliminary.

SPECIFICATIONS

Portland cement used in Canada has to conform with the specifications of the CSA Standard A5-1961, published by the Canadian Standards Association. This standard covers the three main types of portland cement as follows: Normal, High Early Strength and Sulphate-Resisting portland cements. Many changes have been made in this standard over the years. For the last (fifth) edition of A5, issued in 1961, already 34 revisions have been published. The CSA Committee on Hydraulic Cements is presently considering publishing a completely restyled and revised edition of the Standard which will include new specifications for the Modified and Low Heat cements. These types of cements already are being manufactured by several cement companies in Canada and are designed for mass concrete used in dam construction.

Though the tensile strength requirement was dropped from the Standard, there is a good possibility that the present compressive strength requirements will be increased in the new edition of the A5 Standard.

Masonry cement produced in Canada has to conform to the CSA Standard A8-1956. This type of cement is also sold under other names – Mortar Cement, Mason's Cement, Brick Cement, Mortar Mix, etc. Today's masonry cements meet CSA specification A8 Type H and L. Also in this standard many changes have been made over the years. For the 1956 edition of A8 already 19 revisions have been published.

At the 1968 Annual Meeting of the Committee on Hydraulic Cements it was proposed to revise both standards C5 and C8 by converting them entirely to the ton unit. All references to the traditional cement measuring unit, the 350-lb barrel, shall be discarded and replaced by the 2000-lb ton unit. Also the conventional cement packaging unit, known as a bag, will be reduced from 87½ to 80 pounds net, which is a simple fraction of the ton, making it 25 bags to the ton of the cement. After approval by the Committee these revisions will be published in 1969.

In the new, restyled edition both CSA standards C5 and C8 will be combined in one publication.

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).

PRICES

Prices of cement vary depending on supply and demand, quantity of shipment, location of the point of delivery and the type of cement.

The average value of all Canadian shipments in 1967 amounted to $17.91 per ton. This increased to $18.91 per ton in 1968 and ranged from a high of $29.95 per ton for Saskatchewan shipments to a low of $14.86 per ton for Newfoundland shipments.

TARIFFS

Item No.		Most Favoured Nation					
		Before Jan. 1/68	On and after Jan. 1/68	On and after Jan. 1/69	On and after Jan. 1/70	On and after Jan. 1/71	On and after Jan. 1/72
CANADA							
29000-1	Portland and other hydraulic cement, n.o.p.; cement clinker	8¢ per 100 lb	3½¢ per 100 lb	3¢ per 100 lb	2¢ per 100 lb	1¢ per 100 lb	free
29005-1	White, non-staining, Portland cement	"	7¢ per 100 lb	6¢ per 100 lb	5¢ per 100 lb	4¢ per 100 lb	

Source: The Custom Tariff and Amendments, March 1969

Item No.		Before Jan. 1/68	On and after Jan. 1/68	On and after Jan. 1/69	On and after Jan. 1/70	On and after Jan. 1/71	On and after Jan. 1/72
UNITED STATES							
511.11	White non-staining Portland cement	3¢ per 100 lb incl. wt. of container	2.5¢ per 100 lb incl. wt. of container	2¢ per 100 lb incl. wt. of container	2¢ per 100 lb incl. wt. of container	1.5¢ per 100 lb incl. wt. of container	1¢ per 100 lb incl. wt. of container

TARIFFS (cont'd)

UNITED STATES (cont'd)

511.14	Other cement and cement clinker	2.25¢ per 100 incl. wt. of container	1.5¢ per 100 lb incl. wt. of container	1.3¢ per 100 lb incl. wt. of container	0.9¢ per 100 lb incl. wt. of container	0.4¢ per 100 lb incl. wt. of container	free
511.21	Hydraulic cement concrete	5%	4%	3%	2%	1%	free
511.25	Other concrete mixes	15%	13%	12%	10%	9%	7.5%

Source: Tariff Schedules of the United States Annotated (1969)

Chromium

G.P. WIGLE*

Canada's imports of chromium in ores and concentrates in 1968 were 22,401 tons valued at $1.7 million compared with 34,485 tons valued at $2.5 million in 1967. Imports of ferrochromium were 15,045 tons valued at $3.6 million compared with 21,740 tons valued at $5.5 million in 1967.

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 pigments, dyes, leather tanning, electroplating and fungicides.

Canada is not a producer of chromite which is the principal ore mineral of chromium. During periods of emergency, it has been mined in the Eastern Townships of Quebec, where many small, irregular, and disseminated occurrences are found. Chromite discoveries, of no present commercial value, are also known in Manitoba, Newfoundland and British Columbia. The Bird River deposits in the Lac du Bonnet district of Manitoba are large low-grade occurrences averaging about 26 per cent Cr_2O_3 and 12 per cent iron with a low chromium-to-iron ratio of about 1.4 to 1.

British Columbia records a shipment of 670 tons of chromite from Cascade in 1918 and one of 126 tons from Scottie Creek in 1929. The shipment from Cascade came from a mining property adjacent to the United States border and about 2 miles southeast of Cascade. The chromite occurs in lenses and disseminations in highly serpentinized dunite. Chromex Nickel Mines Ltd. and its subsidiary Hunter Point Explorations Ltd. acquired the property and did exploration and diamond drilling in 1967 and 1968. It was reported in November 1968 that significant nickel values were indicated in assays of diamond-drill core over a wide zone.

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 range of ferroalloys include 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; Crucible Steel of Canada Ltd.; Fahralloy Canada Limited; and The Steel Company of Canada, Limited. Canadian companies manufacturing refractories as a primary product used 49,104 tons of imported chrome ore valued at $2.07 million in 1967 compared with 44,874 tons valued at $1.9 million in 1966. Among these 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.

CHROMIUM PRODUCTION AND TRADE

Estimated world mine production of chromite, not including Rhodesia, was 4.97 million tons in 1968 compared with 5.11 million tons in 1967. The Republic of South Africa, USSR, Turkey and the Philippines supplied the major part of the world's chromite. The United Nations embargo on chromium ore from Rhodesia curtailed supplies from that country, previously a principal supplier of high-grade

* Mineral Resources Branch.

TABLE 1

Canada, Chromium Trade and Consumption, 1967-68

	1967		1968P	
	Short Tons	$	Short Tons	$
Imports				
Chromium in ores and concentrates				
United States	18,799	1,395,000	9,688	861,000
Philippines	7,691	539,000	4,099	333,000
Republic of South Africa	469	18,000	3,826	156,000
Cyprus	2,951	191,000	3,276	215,000
Ireland	1,312	150,000	990	119,000
Turkey	1,613	121,000	522	51,000
Other countries	1,650	112,000	–	–
Total	34,485	2,526,000	22,401	1,735,000
Ferrochromium				
Republic of South Africa	13,592	3,225,000	11,686	2,676,000
United States	1,476	466,000	2,169	622,000
France	4,596	1,417,000	948	277,000
Norway	263	65,000	125	30,000
Other countries	1,813	361,000	117	34,000
Total	21,740	5,534,000	15,045	3,639,000
Chromic acid (chromium trioxide)				
Japan	16	8,000	61	26,000
Britain	31	19,000	50	27,000
United States	143	92,000	18	21,000
Other countries	32	12,000	8	3,000
Total	222	131,000	137	77,000
Chromium sulphates, basic, for tanning				
United States	725	167,000	548	134,000
Britain	341	69,000	268	50,000
Japan	7	1,000	133	22,000
Republic of South Africa	20	3,000	100	14,000
Other countries	–	–	2	1,000
Total	1,093	240,000	1,051	221,000
Chrome dyestuffs				
Japan	6	7,000	37	40,000
Britain	18	36,000	21	34,000
United States	32	73,000	15	39,000
Switzerland	13	45,000	15	67,000
West Germany	38	96,000	15	39,000
France	8	23,000	6	17,000
Other countries	4	9,000	6	10,000
Total	119	289,000	115	246,000
Consumption				
Chromite	70,549			

Source: Dominion Bureau of Statistics.
P Preliminary; – Nil; . . Not available.

TABLE 2

Canada, Chromium Trade and Consumption, 1959-68
(short tons)

	Imports		Exports	Consumption[2]	
	Chro-mite[1]	Ferro-chro-mium[2]	Ferro-chro-mium[2]	Chro-mite	Ferro-chro-mium
1959	48,678	. .	7,514	58,532	8,150
1960	59,023	. .	4,611	54,331	8,827
1961	71,268	. .	1,642	52,134	8,046
1962	71,969	. .	6,602	70,342	9,452
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
1968P	22,401	15,045	1	. .	. .

Source: Dominion Bureau of Statistics.

[1] To 1963, gross weight; from 1964, chromium content.
[2] Gross weight. P Preliminary; . . Not available; – Nil.

chromite. The price of Russian chromite, 54-56 per cent Cr_2O_3, 4:1 chromium to iron ratio, was quoted at U.S. $30.50 – $33 in 1967, U.S. $36.50 – $40 in 1968, and U.S. $45.40 – $49.20 for 1969 delivery.* Russia supplied 30 per cent of U.S. chromite in the first 9 months of 1968, compared with 24 per cent during 1967.

Chromite production in the Republic of South Africa was 632,955 tons in the first 6 months of 1968 compared with 616,363 tons in the first half of 1967. Local sales of chromite in South Africa, principally to supply the growing domestic ferrochromium industry, increased to 142,576 tons during January to June 1968 from 124,768 tons in the same period of 1967. Chrome sands, a relatively new product prepared for use in foundry moulds, were exported in the amount of 11,856 tons during January to June 1968.**

The United States is the largest importer and consumer of chromite and relied exclusively on imported supplies. U.S. imports of chromite in 1968 were an estimated 1,200,000 tons and consumption was 1,300,000 tons compared with 1,240,962 tons imported for consumption and 1,353,684 tons consumed in 1967.* The metallurgical industry used approximately 61 per cent of 1968 U.S. consumption, the refractory industries 24 per cent, and the chemical industry 15 per cent. The largest supplier to the U.S. in the first 11 months of 1968 was the Republic of South Africa followed by the USSR, Turkey and the Philippines.

CHROMIUM ORE AND ITS USES

Chromite is the only commercially important ore-mineral of chromium. The theoretical composition of chromite is $FeO.Cr_2O_3$ with a chromic oxide (Cr_2O_3) content of 68 per cent. In fact, most chromite is a combination of oxides of chromium and iron with varying amounts of magnesium and aluminum and has the general formula $(Fe, Mg)O(Cr,Al,Fe)_2O_3$. Chromite seldom contains more than 50 to 55 per cent chromic oxide but Russia does, however, produce high-grade chromite containing 54 to 56 per cent Cr_2O_3. Representative analyses of chromium ores are listed in Table 5.

Variations in chemical and physical properties are the basis for grading the ores into three main groups: metallurgical, refractory and chemical grades. The metallurgical industry of the United States, during the years 1963 to 1967 inclusive, used about 58 per cent of U.S. chromite consumption; the refractory industry 28 per cent and the chemical industry about 14 per cent.

Metallurgical Chromite

In 1967, 95 per cent of the chromite used by the U.S. metallurgical industry averaged 50 per cent Cr_2O_3. Seventy-seven per cent of this metallurgical-grade ore

TABLE 3

World Production of Chromium Ore, 1966-68
(thousands of short tons)

	1966	1967	1968e
USSR	1,653r	1,731	1,700
Republic of South Africa	1,169	1,267	1,200
Philippines	617	463	500
Turkey	583r	678	600
Rhodesia	. .	. .	. .
Albania	345r	349e	350
Iran	193e	198e	200
India	85	114	100
Other countries	329	311	320
Total	4,970	5,110	4,970

Source: U.S. Bureau of Mines, Minerals Yearbook 1966, 1967. 1968 Estimated.

e Estimated; r Revised; . . Not available.

* U.S. Bureau of Mines, Mineral Industry Surveys, December 23. 1968.
** Minerals – A Report for the Republic of South Africa, January–June 1968.

TABLE 4

Consumption of Chromite and Tenor of Ore Used by Primary Consumer Groups in the United States (thousand short tons)

Year	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 (%)
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

Source: Preprint from 1967 U.S. Bureau of Mines Minerals Yearbook.

had a chromium-to-iron ratio of 3:1 or more; 14 per cent was between 3:1 and 2:1; and only 9 per cent was less than 2:1.

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

Ferrochromium is most commonly made by reducing chromite with coke in open-top submerged-arc electric furnaces. 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 steels in which both chromium and carbon are required. Low-carbon ferrochromium, 60 to 73 per cent chromium, 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 as a refractory because of its high melting point, moderate thermal expansion, and its chemically neutral nature. 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 silica and iron content should be not over 10 and 5 per cent respectively; chromic oxide (Cr_2O_3) and alumina (Al_2O_3) combined should be not less than 57 per cent. The ore should be hard and lumpy and above 10-mesh in size. Chromite fines are suitable for the manufacture of refractory brick cement and chrome-magnesite brick. Chromite refractories have a chemically neutral character and are used extensively for the lining of furnaces and hot-metal ladles. 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

The chemical industry uses chromite averaging about 45 per cent Cr_2O_3; the chromium to iron ratio 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 FeO and 3 per cent silica.

Most chromium chemicals are derived from sodium dichromate manufactured from chromite. 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.

TABLE 5

Representative Analyses of Chromium Ores

Country and Type	Per Cent						Cr:Fe Ratio
	Cr_2O_3	Total Fe	Al_2O_3	MgO	CaO	SiO_2	
Rhodesia							
(Selukwe)							
Metallurgical	47	9.34	12.64	15.50	1.80	5.70	3.4 :1
Refractory	42.6	12.2	13.80	15.80	.32	8.60	2.4 :1
(Dyke)							
Refractory	50.70	12.75	13.00	13.20	.75	4.33	2.7 :1
Metallurgical	48.50	14.2	11.50	13.40	.08	5.6	2.4 :1
Russia							
Metallurgical	53.90	9.80	9.60	13.30	1.1	5.80	3.76:1
Refractory	39.10	10.90	17.4	16.10	.7	9.4	2.5 :1
Turkey							
Metallurgical	48.30	10.95	13.00	16.84	.95	5.07	3.01:1
Refractory	37.00	11.80	24.34	17.73	.22	4.33	2.36:1
Philippines							
(Masinloc)							
Refractory	33.35	10.30	28.23	19.56	.45	4.58	2.2 :1
South Africa		FeO					
Chrome Concentrate	50.7	21.0	11.9	12.8	0.1	1.6	. .
	49.2	22.6	13.9	11.7	. .	1.9	. .
Friable Ore	45.2	26.6	15.4	9.6	0.9	2.1	. .
Hard, Lumpy Ore	49.7	20.9	12.0	13.0	0.1	2.5	. .
	42.5	25.0	15.0	12.0	0.1	4.0	. .

Sources: *E & MJ Metal and Mineral Markets,* Market Guide, Chrome, May 1966, and, Minerals – A Report for the Republic of South Africa, April - June 1968.

PRICES

Chrome prices in United States, as quoted by *Metals Week,* December 30, 1968. were:

Chrome Ore
per long ton, dry basis, subject to penalties if guarantees not met, f.o.b. cars Atlantic ports; term contracts (subject to negotiation) are generally lower

Transvaal	
$44\% Cr_2O_3$, no ratio	\$19-\$21.50
Turkish	
$48\% Cr_2O_3$, 3 to 1 ratio	\$37.50-\$38.50
Russian	
$48\% Cr_2O_3$, 4 to 1 ratio	\$40-\$42

Chromium Metal

– electrolytic, 99.8%, f.o.b. shipping point, per lb	96¢
– vacuum melting (pellets)	99¢
– 9% C	136.5¢
– aluminothermic, per lb, delivered	
– 98.5%	96¢
– 99.25%	99¢

Ferrochrome
per lb chrome content, f.o.b. shipping point, freight equalized to nearest main producer, carload lots, lump, bulk

High carbon	
67-71% Cr, 4-6% C or 6-8% C	19.7¢
Low carbon	
67-73% Cr,	
0.025% C	26.1¢
0.05% C	25.1¢
Simplex low carbon	
No. 1 - 0.025% C	25.1¢
No. 2 - 0.01% C	26.1¢
36/40 ferrochrome silicon, 0.05% C	11.6¢
40/43 ferrochrome silicon, 0.05% C	12.5¢

Charge chrome	
63-71% Cr, 3% Si, 0.04% S,	
4.5 - 6% C	16.0¢
Blocking chrome	
10 - 14% Si	18.6¢
14 - 17% Si	19.6¢

TARIFFS

	British Preferential	Most Favoured Nation	General
CANADA			
Chrome ore	free	free	free
Chrome metal, in lumps, powder, ingots, blocks or bars and scrap of alloy metal containing chromium for use in alloying	free	free	free
Ferrochromium	free	5%	5%
Chromium trioxide for use in manufacture of tinplate	free	free	25%
UNITED STATES			
Chrome ore		free	
Chromium metal, unwrought (duty on waste and scrap suspended)			
On and after Jan. 1, 1968		9%	
On and after Jan. 1, 1969		8%	
Chromium metal, wrought			
On and after Jan. 1, 1968		16%	
On and after Jan. 1, 1969		14%	
Ferrochromium			
Not containing over 3% C			
On and after Jan. 1, 1968		7.5%	
On and after Jan. 1, 1969		6.5%	
Containing over 3% C		0.625¢ per lb on Cr content	
Chromic acid			
On and after Jan. 1, 1968		11%	
Jan. 1, 1969		10%	
Chromium carbide			
On and after Jan. 1, 1968		11%	
Jan. 1, 1969		10%	
Chrome brick			
On and after Jan. 1, 1968		22%	
Jan. 1, 1969		20%	
Chrome colours			
On and after Jan. 1, 1968		9%	
Jan. 1, 1969		8%	
Chromate and dichromate			
On and after Jan. 1, 1968		1.55¢ per lb	
Jan. 1, 1969		1.4¢ per lb	

Clays and Clay Products

J. G. BRADY*

Canada is deficient in high-quality clays such as kaolins, fireclays and ball clays and consequently a substantial proportion of these materials are imported. Common clays and shales that are suitable for brick and tile occur in most regions of Canada and are used extensively by the ceramic industry. The central provinces of Ontario and Quebec are particularly deficient in developed deposits of refractory or white-coloured clays. The search for new high-quality deposits and the re-examination of known deposits continued because of the possibility of replacing the large volume of imported clays with domestic supplies.

The term 'clay products' applies to such materials as fireclay refractories, common and facing brick, structural tile, partition tile, drain tile, quarry tile, sewer pipe, conduit and flue lining, which have clay as their principal ingredient; and wall tile, floor tile, electrical porcelain, sanitaryware, dinnerware and pottery, which are prepared bodies of the whiteware type and which, in addition to high-quality clay such as kaolin and ball clay, may contain ground silica, feldspar, nepheline syenite, talc and various other components. A list of ceramic plants is shown in Operators List 6, Ceramic Plants in Canada, published by the Mineral Resources Branch, Department of Energy, Mines and Resources, Ottawa.

PRODUCTION, TRADE AND CONSUMPTION

Statistics on production, trade and consumption of clay and clay products are shown in Tables 1 to 6. Preliminary production, export and import figures are available for 1968 and appear in Tables 1 and 2. The production figures shown in Tables 3 and 4 for whitewares and refractories are the latest available and include those for 1965, 1966 and 1967. The general production trend, as shown from preliminary figures in Tables 1, 3 and 4 is upward but the preliminary values for imports and exports in 1968, Table 2 are lower than the final ones for 1967.

A total of 131 plants manufactured clay products using domestic or imported clays. About 20 of this total includes plants, most of which are of a substantial size, that manufacture art pottery. Many small potteries are not included in this total because of their limited commercial operation. Brick and tile plants make up the largest group, where 62 manufactured such clay products as facing brick, common brick, structural tile, quarry tile and drain tile primarily from local, common clays and shales. Six plants manufactured sewer pipe from domestic or imported clays. Most of the 18 plants manufacturing refractories used imported clay as the principal ingredient in many of their products. Only 4 of these plants, all in western Canada, used domestic clays.

Five whiteware sanitaryware plants, eight electrical porcelain plants, five wall tile plants (including two that also make floor tile), four dinnerware plants, and the majority of the art potteries were the principal users of ceramic-grade china clay and ball clays, which are imported mainly from the United States and Britain. Some of the art potteries and two of the dinnerware plants imported unfinished ware and completed the manufacturing process by glazing or decorating it.

The quantity of china clay used in Canada continued to rise (Table 6). No statistics on the quantity of fireclay and ball clay consumed are available. About 2.5 million tons of domestic clay are consumed in the products included in Table 1.

*Mineral Processing Division, Mines Branch.

USES, NATURE AND LOCATION OF CLAY AND SHALE DEPOSITS

CHINA CLAY (KAOLIN)

China clay, frequently referred to as kaolin, is a high-quality material used as a filler and coater in the paper industry, a raw material in ceramic products and a filler for rubber and other products. The properties needed in the paper industry are intense whiteness, freedom from abrasive grit and high coating retention. In the ceramic industry it is used as a refractory raw material. In prepared whiteware bodies it is used along with such materials as nepheline syenite, silica, feldspar and talc, for the manufacture of such products as wall tile, floor tile, sanitaryware, dinnerware, pottery and electrical porcelain.

TABLE 1

Canada, Production of Clay and Clay Products from Domestic Sources, 1967-68

		1967		1968p	
		Quantities	$	Quantities	$
Production, shipments from domestic sources					
By main classes					
Clays, including bentonite			1,356,390		*
Clay products from					
Common clay			34,260,324		38,190,300
Stoneware clay			6,128,155		6,120,664
Fireclay			869,405		*
Other			1,742,551		1,953,519
Total			44,356,825		46,264,483
Byproducts					
Clay					
Fireclay			1,356,390		
Other clay, including bentonite					
Fireclay blocks and shapes		..	17,729		
Firebrick	No.	6,708,960	851,676		
Brick					
Soft mud process					
Face	No.	3,424,000	226,247		
Common	"	1,956,910	78,553		
Stiff mud process					
Face	"	415,824,815	21,078,707		
Common	"	27,443,456	466,227		
Dry process					
Face	"	74,726,925	4,363,174		
Common	"	1,502,744	35,187		
Fancy or ornamental	"	14,041,483	973,382		
Sewer brick	"	2,604,974	94,447		
Paving brick	"	708,270	53,329		
Structural tile	s.t.	48,048	1,059,164		
Floor tile	sq.ft.	170,980	84,528		
Drain tile	No.	77,641,304	5,747,379		
Sewer pipe	ft.	6,763,320	3,720,115		
Flue linings	"	1,629,846	1,024,578		
Pottery		..	1,383,462		
Other products		..	1,742,551		
Total			44,356,825		46,264,483

Source: Dominion Bureau of Statistics.
*Included under Other.
pPreliminary; – Nil; .. Not available.

TABLE 2

Canada, Imports and Exports of Clay, Clay Products and Refractories

		1967		1968p	
		Quantities	$	Quantities	$
Imports					
Clay, clay products and refractories					
Bentonite	s.t.	219,862	2,154,000	307,699	2,826,000
Drilling mud	"	7,811	885,000	8,141	884,000
China clay, ground or unground	"	190,311	4,549,000	180,296	4,325,000
Fireclay, ground or unground	"	40,508	602,000	50,146	744,000
Clays, ground or unground	"	89,335	1,255,000	59,070	990,000
Clays and earth, activated	"	6,510	933,000	6,205	953,000
Brick, building					
glazed	M	3,026	208,000	2,349	177,000
n.e.s.	"	17,272	1,027,000	19,863	1,220,000
Building blocks	"	..	473,000	..	298,000
Earthenware tile					
under 2-1/2 x 2-1/2"	sq.ft.	11,645,282	2,407,000	12,325,694	2,587,000
over 2-1/2 x 2-1/2"	"	12,008,639	2,281,000	13,041,300	2,365,000
Claybrick, blocks, and tiles, n.e.s.	M	..	129,000	..	110,000
Firebrick					
Alumina	"	3,482	4,472,000	3,520	3,450,000
Chrome	"	732	1,139,000	1,066	695,000
Magnesite	"	462	1,379,000	749	2,135,000
Silica	"	1,941	1,606,000	1,153	977,000
n.e.s.	"	45,556	11,644,000	37,909	11,579,000
Refractory cements and mortars		..	1,711,000	..	1,837,000
Pottery settings and firing supplies		..	273,000	..	272,000
Crude refractory materials	s.t.	5,689	437,000	5,312	450,000
Grog (refractory scrap)	"	16,386	576,000	15,690	635,000
Refractories, n.e.s.		..	1,994,000	..	1,490,000
Acid-proof brick		..	272,000	..	228,000
Tableware, ceramic		..	25,251,000	..	21,233,000
Porcelain insulating fittings		..	3,073,000	..	2,971,000
Total clay products and refractories		..	70,730,000	..	65,431,000
By main countries					
United States			37,314,000		36,041,000
Britain			21,073,000		17,905,000
Japan			7,272,000		6,849,000
West Germany			1,355,000		1,409,000
Hong Kong			605,000		726,000
France			836,000		472,000
Ireland			605,000		332,000
Italy			350,000		305,000
East Germany			173,000		164,000
Denmark			225,000		76,000
Czechoslovakia			236,000		66,000
Other countries			686,000		1,086,000
Total			70,730,000		65,431,000

TABLE 2 (Cont'd)

		1967		1968P	
		Quantities	$	Quantities	$
Exports					
Clays, clay products and refractories					
Clays, ground and unground	s.t.	277	27,000	732	43,000
Crude refractory materials	"	1,114,162	2,605,000	900,384	1,476,000
Building brick, clay	M	13,181	1,049,000	15,412	1,545,000
Clay bricks, blocks, tiles, n.e.s.		..	413,000	..	383,000
Firebrick and similar shapes		..	6,215,000	..	5,341,000
Refractories, n.e.s.		..	384,000	..	313,000
High tension insulators and fittings		..	1,985,000	..	1,134,000
Tableware		..	1,062,000	..	1,589,000
Total clays, clay products and refractories			13,740,000		11,824,000
By main countries					
United States			10,202,000		8,432,000
Chile			203,000		526,000
Greece			125,000		158,000
Puerto Rico			284,000		107,000
Sweden			127,000		98,000
New Zealand			134,000		78,000
Bahamas			151,000		72,000
Pakistan			132,000		47,000
Republic of South Africa			623,000		11,000
Tanzania			117,000		2,000
Ireland			134,000		1,000
Other countries			1,508,000		2,292,000
Total			13,740,000		11,824,000

Source: Dominion Bureau of Statistics.
.. Not available;–Nil; n.e.s. Not elsewhere specified; M = 1,000.

China clay is used as a source of alumina and silica in the whiteware industries. It also imparts a degree of plasticity to the unfired body and helps to maintain a white fired colour.

Because of the problems of beneficiation and the small size of some deposits, none of the crude kaolins known to exist in Canada have been developed. Most occurrences contain a high proportion of quartz, whose particles vary in size from coarse to very fine, and such substances as mica, feldspar, magnetite, pyrite and colloidal iron. In the crude material the percentage of clay, which is principally kaolinite, is frequently small. Attempts to remove impurities from Canadian kaolins have so far not been successful. However, new and improved methods of beneficiation may be effective.

Deposits of sandy kaolin occur near Wood Mountain, Fir Mountain, Knollys, Flintoft and other localities in southern Saskatchewan. Despite considerable work done by the Saskatchewan Government, University of Saskatchewan, and the Federal Government just prior to and just after World War II, no satisfactory method of producing a good commercial kaolin from these deposits has been developed.

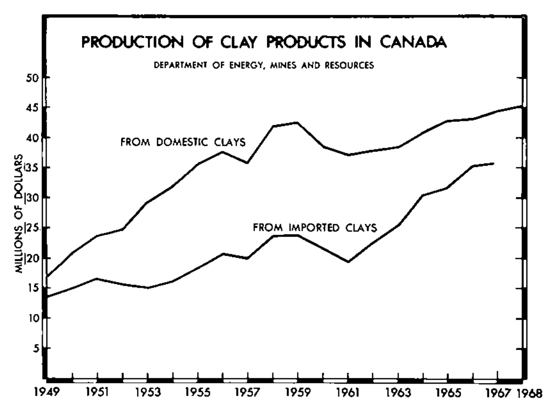


TABLE 3

Canada, Shipments of Clay Products Produced from Imported Clays*, 1965-67

		1965		1966		1967	
		Quantities	$	Quantities	$	Quantities	$
Glazed floor and wall tile	sq.ft.	15,545,578	5,882,000	11,566,676	5,575,000	12,695,874	5,360,000
Electrical porcelains		..	10,068,000	..	12,259,000	..	12,350,000
Pottery, art and decorative ware		..	1,246,000	..	2,976,000	..	2,015,000
Pottery, tableware		..	1,859,000	..	1,534,000	..	1,638,000
All other products		..	13,030,000	..	13,734,000	..	14,361,000

Source: Dominion Bureau of Statistics.
*Does not include refractories.
.. Not available.

TABLE 4

Canada, Shipments of Refractories

		1965		1966		1967	
		Quantities	$	Quantities	$	Quantities	$
Fireclay blocks and shapes		..	69,465	..	98,183	..	17,729
Firebrick	M	4,836	665,748	4,836	669,011	6,709	851,676
Other firebrick and shapes*		..	16,227,787	..	15,942,806	..	16,686,595
Cements, mortars, castables and other refractory products		..	11,202,000r	..	12,894,000	..	14,449,000

Source: Dominion Bureau of Statistics.
*Includes rigid firebrick, stove linings, and other shapes made from imported clay, chrome ore, magnesite, etc. Silicabrick not included.
.. Not available; rRevised.

A deposit of refractory clay similar to a secondary china clay occurs along the Fraser River near Prince George, British Columbia. The material varies from very plastic to very sandy. The upper beds are considerably iron-stained. This material has been investigated as a source of kaolin, as a fireclay and as a raw material for facing brick.

Various kaolinitic-rock deposits have been investigated in Manitoba, but so far none have been considered suitable for commercial development. 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. Kaolinic clays have also been reported near Kergwenan.

Kaolin-bearing rock occurs in Quebec at St. Remi d'Amherst, Papineau County; Brebeuf, Terrebonne County; Point Comfort, on Thirty-one Mile Lake, Gatineau County; and Chateau Richer, Montmorency County. The Quebec deposits, in general, contain an excessive amount of quartz and iron minerals. The kaolinite content is variable but is usually less than 50 per cent. The Chateau Richer material is mainly feldspar with about 25 per cent kaolinite. In recent years, various companies have shown considerable interest in Quebec's kaolin-bearing deposits because of their kaolinite content and because of the possible uses of the unbeneficiated material for the facing-brick and other industries. The possibility of there being a larger than suspected tonnage of kaolin at the Brebeuf deposit is being investigated by a commercial clay company.

Table 5

Canada, Clay and Clay Products Production, and Trade, 1959-68
($ millions)

	Production				
	Domestic Clays[1]	Imported Clays[2]	Total	Imports[3]	Exports[3]
1959	42.5	23.9	66.4	48.1	5.1
1960	38.2	21.5	59.7	46.7	5.3
1961	37.0	19.4	56.4	47.1	5.8
1962	37.8	22.5	60.3	48.3	5.4
1963	38.2	25.2	63.4	43.9	7.6
1964	40.8	30.2	71.0	54.7	8.9
1965	42.8	31.4	74.2	59.4	10.3
1966	43.0	35.9	78.9	71.7	12.6
1967	44.3	35.5	79.8	70.7	13.7
1968[p]	46.2	..	..	65.4	11.8

Source: Dominion Bureau of Statistics.
[1]Production (shipments) of clay and clay products from domestic material.
[2]Production (shipments) of clay products from imported clay; from 1961 does not include refractories.
[3]Includes refractories.
[p]Preliminary; .. Not available.

TABLE 6

Canada, Consumption (Available Data) of China Clay by Industries, 1966-67
(short tons)

	1966	1967
Ceramic products	11,423	14,354
Paint and varnish	2,610	2,848
Paper and paper products	122,519	122,475
Rubber and linoleum	10,959	9,992
Other products*	14,126	18,384
Total	161,637	168,053

Source: Dominion Bureau of Statistics.
*Includes miscellaneous chemicals, cleansers, detergents, soaps, medicinals and pharmaceuticals and other miscellaneous products.

Extensive deposits of kaolin-sand mixtures occur in northern Ontario along the Missinaibi and Mattagami Rivers. Good quality clays and glass sands have been obtained from this area and interest remains high in the possibilities of this area. Algocen Mines Limited have undertaken a large development program on deposits along the Missinaibi River, north of Hearst. The distance from markets, and the difficult terrain and climate of the area have hindered development.

BALL CLAY

Ball clays are used in whitewares, where they impart plasticity and a high green strength to the bodies. They fire white or light cream, which does not interfere with the fired colour of the whiteware products. Being extremely refractory, they are used as a plastic bond clay in various types of refractory products.

Ball clays obtained in Canada are mineralogically similar to high-grade plastic fireclays. They are made up principally of fine-particle kaolinite and quartz.

In Canada, ball clays are known to occur only in the Whitemud formation of southern Saskatchewan. Good-quality deposits are known to exist 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. It has been tested in the United States. The lack of proper quality control, the distance from large markets and lack of reserves have been the principal disadvantages affecting the use of this material. Some ball clay from the Flintoff area is being used for white-to-buff facing brick and for household pottery and crocks.

FIRECLAY

Canadian fireclays are used principally for the manufacture of medium and high-duty firebrick and refractory specialties. High-duty refractories require raw materials having a PCE (pyrometric cone equivalent) of about 31½ to 32½ (approximately 1,699 to 1,724°C). Intermediate-duty refractories require raw materials having a PCE of about 29 (approximately 1,659°C) or higher. Clays having a PCE of less than 29 but greater than 15 (approximately 1,430°C) may be suitable for low-duty refractories or ladle brick as well as for other clay products. No known Canadian fireclays 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 cone 33 was examined at the Mines Branch, Ottawa.

Various grades of good-quality fireclays occur in the Whitemud formation in Saskatchewan. At a large plant at Claybank, fireclays from nearby pits are used for the manufacture of medium and high-duty refractories and refractory specialties. Good-quality fireclays occur on Sumas Mountain in British Columbia. At a large plant there the better grades are used in the manufacture of products similar to those produced at the Saskatchewan plant. Some fireclay from the Sumas deposit is exported to the United States, and a small quantity is used at plants in Vancouver.

Fireclay and kaolin occur in the James Bay watershed of northern Ontario along the Missinaibi, Abitibi, Moose and Mattagami rivers. Adverse terrain and climate have made exploration difficult, but considerable exploration has been carried out in this area in recent years. Some seams of clay in the deposit at Shubenacadie, Nova Scotia, are sufficiently refractory for medium-duty refractories. Preliminary work has been done on their use for the production of ladle brick. Clay from Musquodoboit, Nova Scotia, has been used by a few foundries in the Atlantic Provinces.

Ontario and Quebec have no producing domestic sources of fireclay. These industrial provinces import most of their requirements from the United States.

STONEWARE CLAY

Stoneware clays are similar to low-grade plastic fireclays. They are used extensively in sewer pipe, flue liners, facing brick, pottery, stoneware crocks and jugs and chemical stoneware. As in fireclays the principal clay mineral is kaolinite or a similar clay mineral.

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 now located in the Alberta Cypress Hills, southeast of Medicine Hat, and at Avonlea, Saskatchewan.

Stoneware or low-grade fireclays occur on Sumas Mountain, near Abbotsford, British Columbia. They are used in the manufacture of sewer pipe, flue lining, facing brick and tile. Similar types of materials occur at Shubenacadie and Musquodoboit in Nova Scotia. 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, and in British Columbia at Chimney Creek Bridge, Williams Lake, Quesnel and close to the Alaska Highway. Quebec and Ontario import stoneware clay from the United States for the manufacture of facing brick and sewer pipe.

COMMON CLAY AND SHALE

Common clays and shales are the principal raw materials available in Canada for the manufacture of clay products. They are used mainly for the manufacture of common and facing brick, structural tile, partition tile, conduit, quarry tile and drain tile. Some common Canadian clays are mixed with stoneware clay for the manufacture of such products as facing brick, sewer pipe and flue lining.

Because of the presence of iron, common clays and shales usually fire salmon or red. Their fusion points are low – usually well below cone 15 (approximately 1,430°C), which is considered to be the lower limit of the softening point for fireclays. Ordinarily, they 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 many others. The clay minerals are chiefly illitic, chloritic or illitic-chloritic, although frequently a member of the montmorillonite or kaolin group, vermiculite or various mixed layer clay minerals are found in them.

Clays and shales suitable for the manufacture of clay products usually contain 25 to 35 per cent small-particle quartz. If the quartz exceeds this proportion and there are other non-plastic materials, the plasticity of the clay is reduced and quality of the ware is lowered. Many clays and shales contain calcite or dolomite or both. If present in sufficient quantities, these cause the clay to fire buff and adversely affect the fired strength and density. Common clays and shales are usually higher in alkalis, alkaline materials and iron-bearing minerals and much lower in alumina than the high-quality stoneware clays, fireclays and ball clays. Since shales are less plastic than clays, they must be finely ground when used for extruded ware so that plasticity may be developed if possible, or they must be combined with a plastic clay or some plasticizer.

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. Most of the common surface clays are the result of severe glaciation which has influenced the nature of deposits that cover the bedrock. These Pleistocene deposits are of interest to the ceramic industry and include stoneless marine and nonmarine sediments, re-worked glacial till, interglacial clays, and flood plain clays. Some Tertiary and Cretaceous deposits that are useful to the ceramic industry occur close to the surface. The Pleistocene clays melt at a low temperature, while those of the Cretaceous and Tertiary vary widely in their refractoriness, depending on the locality and formation.

It has been found that, in general, the common shales (as opposed to the common surface clays) provide the best source of raw material for brickmaking. 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 the west, they are very refractory.

BENTONITE

Bentonite is the subject of another review in the present series.

PRICES

According to *Oil, Paint and Drug Reporter* of December 30, 1968, United States clay prices were as follows:

Ball clay		
Domestic, air floated, bags, car lots, f.o.b. Atlantic ports	per ton	\$49.00 - \$50.75
Domestic, crushed, moisture-repellant, bulk, car lots, f.o.b. Tennessee	per ton	\$8.00 - \$11.25
Imported, air floated, bags, car lots, f.o.b. Atlantic ports	per ton	\$49.50 - \$50.75
lump, bulk, f.o.b. Atlantic ports	per ton	\$31.50 - \$37.50
China clay (kaolin)		
Water washed, calcined, bulk, car lots, f.o.b. Georgia	per ton	\$57.80 - \$58.50
Dry-ground, air floated, soft same basis	per ton	\$12.50

TARIFFS

Item No.			Most Favoured Nation					
			Before Jan. 1, 1968	On and After Jan. 1, 1968	On and After Jan. 1, 1969	On and After Jan. 1, 1970	On and After Jan. 1, 1971	On and After Jan. 1, 1972
CANADA								
29500-1	Clays, including china clay, fire clay, and pipe clay		free	free	free	free	free	free
	Varying tariffs are in effect on clay products, glazed and unglazed and clay building materials.							
UNITED STATES								
521.41	China clay or kaolin	per l.t.	67¢	60¢	53¢	46¢	40¢	33¢
521.51	Fuller's earth, not beneficiated	" "	50¢	45¢	40¢	35¢	30¢	25¢
521.54	Fuller's earth, beneficiated	" "	21%	18.5%	16.5%	14.5%	12.5%	10.5%
521.61	Bentonite	" "	81.25¢	73¢	65¢	56¢	48¢	40¢
521.71	Ball clay, not beneficiated	" "	62¢	58¢	54¢	50¢	46¢	42¢
521.74	Ball clay, beneficiated	" "	\$1.21	\$1.13	\$1.06	99¢	92¢	85¢
521.81	Other clays, not beneficiated	" "	50¢	40¢	30¢	20¢	10¢	free
521.84	Other clays, beneficiated	" "	\$1.00	90¢	80¢	70¢	60¢	50¢
	Varying tariffs are in effect on clay products							

Coal and Coke

R.A. SIMPSON and L.P. CHRISMAS*

Coal, long a staple energy commodity in Canada prior to the 1950's but exhibiting a declining production in recent times, seemed destined to a minor role in the mineral economy for some time to come. The large coal reserves in western Canada were not so attractive to the Canadian market as were the more recently found oil and gas resources. In addition, the export market to Japan was supplied by coal that required transportation subsidies to be competitive. Under these circumstances it was not surprising that the outlook was a gloomy one. However, it was generally accepted that in time North American petroleum and gas resources would be unable to meet continental requirements and then Canadian coal would find its place again as a prominent energy commodity. Both the timing and the rationale of this argument have been proven wrong. The signing of new contracts covering the export of large quantities of Canadian coking coal to Japan, as well as the increasing demand by the Canadian thermal electric industry, have initiated a revival of the coal industry in western Canada, beginning in the immediate future.

Without the buoyancy provided by developments in 1968, any review of the Canadian coal producing industry in 1968 would not have been much different from those of the past decade or so. With the new export contracts either concluded or under negotiation, the year 1968 becomes a memorable turning point in the history of western Canadian coal.

For the industry in eastern Canada, the outlook is much different. Here, the heavily subsidized and declining coal mining industry is being rationalized to enable the coal mining areas to adjust from a reliance primarily on coal, to other forms of economic endeavour.

As summarized in Table 1, aggregate coal production in 1968 was slightly below that for 1967. The substantial decrease in Nova Scotia, together with a sizable increase in Alberta, placed Alberta once again as Canada's top coal producing province. Although production has tended to remain relatively steady during the last 10 years, both imports and exports have increased slightly. Based on the growing demand for coal by Canadian industry and for export purposes, a reasonable forecast is that the annual coal production will approach the 20 million ton† mark well within the next decade.

PRODUCTION AND MINE DEVELOPMENTS

BRITISH COLUMBIA

The principal coal producing region in British Columbia, the East Kootenay area, has large reserves of medium volatile bituminous coal that has excellent coking properties. The thick coal-seams occur within a belt of faulted and disturbed Lower Cretaceous rocks in the Rocky Mountains extending north from the East Kootenay area. The province ranks third in reserves, having about 18 per cent of the coal in Canada.

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* Mineral Resources Branch.

†The short ton (2,000 pounds) is used throughout unless otherwise noted.

TABLE 1

Coal Production, by Types, Provinces and Territories, 1967-68

	1967		1968p	
	Short Tons	$ *	Short Tons	$ *
Bituminous				
Nova Scotia	3,735,473	51,681,004	3,130,332	30,400,187
New Brunswick	837,029	7,489,617	797,234	7,370,119
Alberta	937,591	6,938,387	945,357	7,461,824
British Columbia and Yukon Territory	962,560	7,549,919	863,194	6,464,142
Total	6,472,653	73,658,927	5,736,117	51,696,272
Subbituminous				
Alberta	2,653,297	5,480,027	2,968,444	5,236,345
Lignite				
Saskatchewan	1,996,985	3,620,962	2,250,219	4,164,841
All types				
Canada total	11,122,935	82,759,916	10,954,780	61,097,458

Source: Dominion Bureau of Statistics.

* Coal production values include subvention payments. These payments ceased in April 1968, for Nova Scotia coal.

p Preliminary.

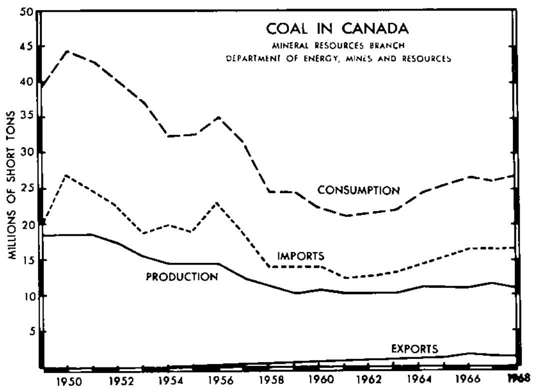
TABLE 2

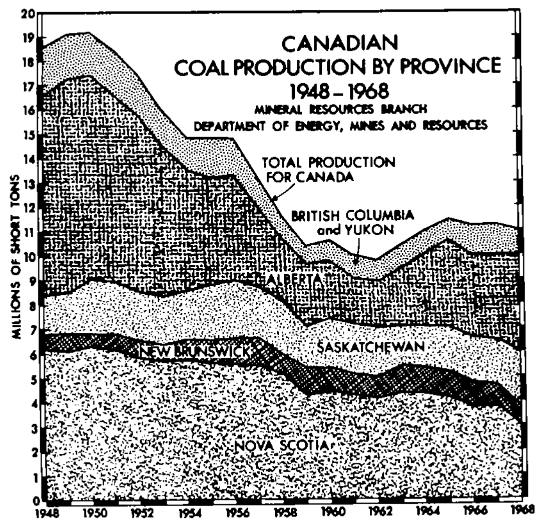
Coal – Production, Imports, Exports and Consumption, 1958-68
(short tons)

	Production	Imports	Exports	Consumption
1958	11,687,110	14,491,315	338,544	26,305,484
1959	10,478,324	14,236,118	473,768	24,675,570
1960	10,737,246	13,564,836	852,921	22,441,481
1961	10,261,420	12,306,498	939,336	21,719,699
1962	10,173,173	12,614,189	893,919	22,375,779
1963	10,413,941	13,370,406	1,054,367	23,736,350
1964	11,150,727	14,989,114	1,291,664	24,662,613
1965	11,415,458	16,595,393	1,225,994	25,750,899
1966	11,153,461	16,436,755	1,228,820	25,263,657
1967	11,122,935	16,114,190	1,338,353	24,967,931
1968	10,954,780	16,616,548	1,447,013	–

Source: Dominion Bureau of Statistics.

– Not available.





Nearly all of British Columbia's 1968 coal production was from the Michel colliery of Kaiser Coal Ltd., situated at Michel, 24 miles northeast of Fernie. Until early 1968, most of the mining in this area was by Crows Nest Industries Limited. This company, which has mined in the Michel area since 1897, had an extensive underground mining operation, some small strip mines, a wash plant and coking facilities. In recent years production from the Michel colliery has varied from 700,000 to 1 million tons per year with the bulk obtained from underground. In early 1968, the Crows Nest Industries coal operations at Fernie were sold to Kaiser Coal Ltd., (name subsequently changed to Kaiser Resources Ltd.) a wholly owned subsidiary of Kaiser Steel Corp. of California.

At the same time, Kaiser concluded a contract to export 45 million long tons of high-grade coking coal having a delivered value estimated at $650 million. The contract covers deliveries over a 15-year period beginning in 1970. In order to meet its obligations, Kaiser is developing a large strip mine near the older operations. To handle the large tonnages of coal and overburden, new modern equipment such as 200-ton diesel-electric trucks will be used in the open pit. Additional production will come from the underground mines, incorporating new modern mining methods possibly using high-pressure water jets to cut the coal from the face. Kaiser is also constructing a coal preparation plant designed to handle from 6.5 to 7 million tons annually. From the preparation plant near Sparwood, the coal will be transported to the Roberts Bank port, now under construction, about 20 miles south of Vancouver, in unit trains for shipment to Japan in large bulk carriers. A modern community at Sparwood is being established to accommodate the working force. It is expected that 400 men will be used in the underground operations, 300 in the strip mining and 200 others for engineering and other functions when the mining operation is in full operation.

The only other coal produced in British Columbia during the year came from Bulkley Valley Collieries, Limited located near Smithers in central British Columbia. In 1968, Forestburg Collieries Limited of Edmonton leased the Bulkley operations, on a royalty basis, to salvage the remaining coal.

Negotiations were in progress during 1968 which could lead to the development of other mines. Two companies outlining coal reserves in British Columbia with an eye on the Japanese markets are Fording Coal Limited, a subsidiary of Canadian Pacific Investments Limited and Cominco Ltd., and Elk River Mining Company, a subsidiary of North American Coal Corporation and Scurry Rainbow Oil Limited. Since Japan's requirement for imported coal has risen by 72 per cent since 1966 and will continue to grow in the future, both companies should have good opportunities to complete contracts with Japanese iron and steel firms.

ALBERTA

About 30 per cent of Canadian coal reserves are in Alberta. Most of these are of bituminous and subbituminous rank but coals of all ranks from lignite to anthracite are present. Because of the great lateral extent of the coal-bearing measures, the continuity of the coal-seams and the evident lack of structural boundaries it is difficult to define the boundaries of a coal-field. However, to indicate the areas generally, reference should be made to the accompanying map.

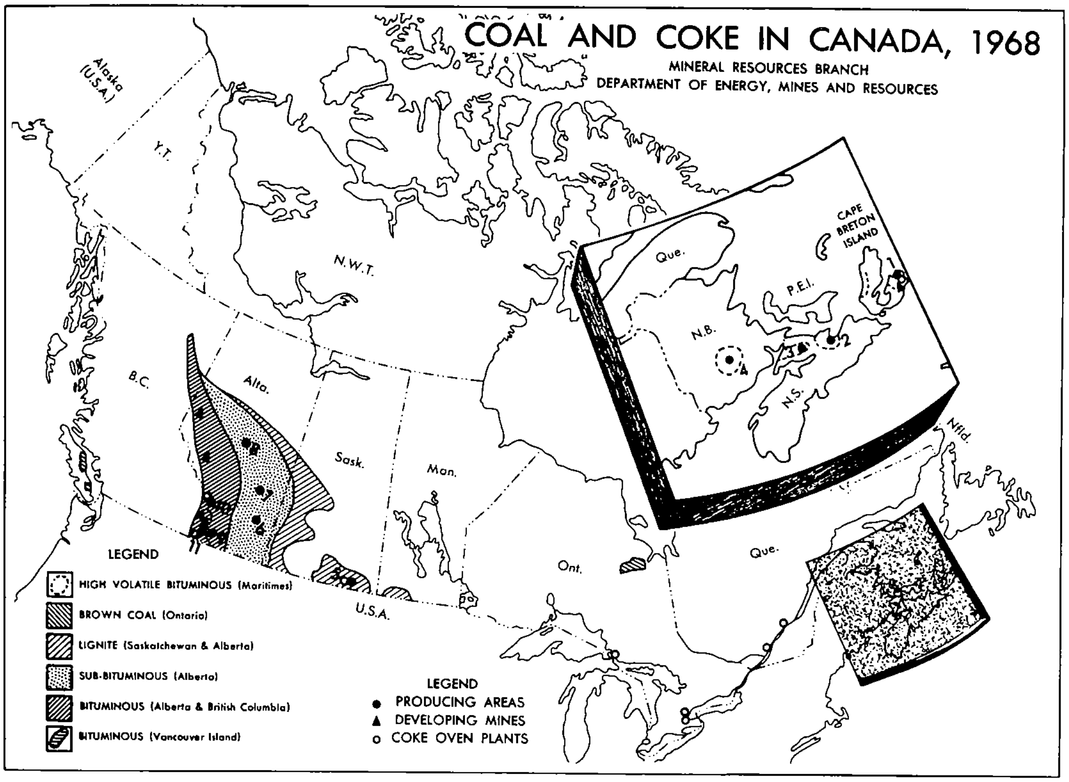


TABLE 3

Principal[1] Coal Mines in Canada – 1968

Map No.[2]	Company and Location	Type of Coal[3]	Type of Mine[4]	Approximate Output (000 tpy)
NOVA SCOTIA				
1.	*Sydney and Inverness Area*			
	Bras d'Or Coal Company, Limited	B(H)	UG	95
	Cape Breton Development Corporation	B(H)	UG	2,725
	Evans Coal Mines Limited	B(H)	UG	35
2.	*Pictou Area*			
	Thorburn Mining Limited	B(H)	UG	110
	Drummond Coal Company Limited	B(H)	UG	55
3.	*Springhill and Joggins Area*			
	River Hebert Coal Company Limited	B(H)	UG	60
	Springhill Coal Mines Limited	B(H)	UG	65
NEW BRUNSWICK				
4.	*Minto Area*			
	Avon Coal Company, Limited	B(H)	S	200
	D.W. & R.A. Mills Limited	B(H)	S	300

TABLE 3 (Cont'd)

Principal[1] Coal Mines in Canada – 1968

Map No.[2]	Company and Location	Type of Coal[3]	Type of Mine[4]	Approximate Output (000 tpy)
NEW BRUNSWICK (Cont'd)				
4. *Minto Area (Cont'd)*				
	Midland Mining Co. Ltd.	B(H)	S	35
	Miramichi Lumber Company (Limited)	B(H)	S	190
	C.H. Nichols Co. Ltd.	B(H)	UG	40
	V.C. McMann, Ltd.	B(H)	UG	30
SASKATCHEWAN				
5. *Souris Valley Area*				
	Battle River Coal Company Limited	Lig	S	620
	Manitoba and Saskatchewan Coal Company Limited	Lig	S	420
	Utility Coals Ltd.	Lig	S	1,225
ALBERTA				
6. *Drumheller and Sheerness Areas*				
	Century Coals Limited	SB	S	100
	Fox Coulee Coals Ltd.	SB	S	45
	Battle River Coal Company Limited	SB	S	100
7. *Castor Area*				
	Battle River Coal Company Limited	SB	S	225
	Forestburg Collieries Limited	SB	S	400
8. *Edmonton and Pembina Areas*				
	Alberta Coal Ltd. (Mines Nos. 419, 1757)	SB	S	1,925
	Star-Key Mines Ltd.	SB	UG	30
9. *Crowsnest Area*				
	Coleman Collieries Limited	B(M)	S & UG	660
10. *Cascade Area*				
	The Canmore Mines, Limited	B(L) & A	S & UG	285
BRITISH COLUMBIA				
11. *East Kootenay Area*				
	Kaiser Coal Ltd.	B(M)	S & UG	900

[1] Producing 25,000 or more tons per year.
[2] See Map for location.
[3] A – Anthracite; B(L) – Bituminous, low volatile; B(M) – Bituminous medium volatile; B(H) – Bituminous, high volatile; SB – Subbituminous; Lig – Lignite.
[4] S – Strip; UG – Underground.

Alberta has the largest number of coal-mines in Canada, although many are small operations with production less than 25,000 tons per year. Bituminous coal is mined by both underground and surface methods in the Foothills belt whereas subbituminous coal is strip-mined in the Alberta plains regions. One exception is an underground subbituminous mine within the city of Edmonton.

In the Foothills region, a large part of the bituminous coal is of excellent coking quality. In 1968 the two producing mines from this area, Coleman Collieries Limited, and The Canmore Mines, Limited produced coal almost exclusively for the Japanese export market. In 1967 Coleman Collieries Limited signed a contract for about 13 million long tons over 15 years. The Canmore Mines, Limited signed a similar but smaller export contract in 1968 for 3.8 million long tons over 10 years. Canmore's mining operations are situated 55 miles west of Calgary near Banff National Park. The 15 to 30 feet thick coal-seam is mined by a combination of underground and surface methods.

In the northern Alberta Foothills region, two other mines were being prepared for production. In April 1968, Luscar Ltd. in partnership with Consolidation Coal Company of Pittsburgh signed a $200 million contract with Japanese iron and steel companies for the export of 15 million long tons of coal over 15 years. Luscar's strip mine is situated about 25 miles south of Hinton in the Coalspur area, once one of the more active mining areas in Alberta. The coal-seam there is about 40 feet thick and is highly folded and faulted. Cardinal River Coals Ltd., the operating company for Luscar Ltd. and Consolidation Coal will be using new large scale open-pit equipment to recover the coal.

In December, McIntyre Coal Mines Limited having coal leases in the Smoky River area 240 miles northwest of Edmonton, Alberta, signed a 15-year agreement to supply 30 million long tons of coking coal to Japanese steel mills. The underground mine is scheduled to begin production in 1970 with pre-production development to start immediately. In order to accommodate the anticipated 1,000 employees, a new town, Grande Cache, is under construction near the mine. The town and mine will be served by the Alberta Resources Railway which joins with the Canadian National Railways main line at Brûlé, west of Hinton, Alberta. The recent completion of a railway to the Smoky River area was a significant factor in the successful negotiation of McIntyre's coal exports contract and it could possibly lead to the development of other coal-mines along its route.

Two of the largest producers of the shallow flat lying coal-seam in the plains area are Alberta Coal Ltd. and its subsidiary, Battle River Coal Company Limited. These two companies dominate coal mining in the plains area with mines at Wabamun near Edmonton, at Halkirk in the Castor area, and at Sheerness. Other large producers include Century Coals Limited and Forestburg Collieries Limited. The prime market for subbituminous coal is coal-fired thermal power plants with smaller amounts used for domestic heating and industrial plants.

SASKATCHEWAN

In Souris Valley of southeastern Saskatchewan, lignite coal is strip-mined by highly productive mining operations owned by Battle River Coal Company Limited (became Alberta Coal Ltd., December 31, 1968), Manitoba and Saskatchewan Coal Company Limited and Utility Coals Ltd. Lignite in this area is part of a field extending from southern Saskatchewan into North Dakota, South Dakota, and Montana. Lignite, at a cost of below 10 cents per million Btu, at the mine is one of the cheapest sources of energy in Canada. As a result, the lignite mines have a sound basic market in the two electric utility plants located within the coal-field at Estevan. Expansion of the plants is expected to raise coal requirements from 1.2 million tons in 1968 to approximately two million tons by the early 1970's. Because of its low unit value,

TABLE 4

Coal Production†, by Type of Mining and Average Output per Man-day, 1968
(short tons)

	Production		Average Output per Man-dayP	
	Underground	Strip	Underground	Strip
Nova Scotia	3,132,321	–	2.604	–
New Brunswick	81,500	715,834	1.682	5.380
Saskatchewan	–	2,250,219	–	60.248
Alberta	936,946	2,988,168	5.003	47.670
British Columbia	559,443	343,846	5.564	17.455
Canada 1968P	4,710,210	6,298,067	3.451*	45.707*
1967	5,477,397	5,918,357	3.505*	39.347*
Total, all mines 1968P	11,008,277		27.627*	
1967	11,395,754		22.120*	

Source: Dominion Bureau of Statistics.
† Production includes quantities put on waste heap.
* Weighted average.
P Preliminary; – Nil.

lignite cannot bear substantial transportation charges, consequently it rapidly loses its competitive position with increasing distance from its point of production. Unit trains would lower costs considerably if greater bulk contracts could be obtained.

ONTARIO

The James Bay coal-field in the Hudson Bay lowlands in northern Ontario has been the scene of renewed exploration activity by Alberta Coal Ltd. A feasibility study conducted during 1967 and 1968 by Alberta Coal Ltd. determined that the James Bay lignite field can be mined at reasonable cost by open-pit methods. However, nearby markets for coal are lacking. The study determined that because of its low heat value, roughly one-half to two-thirds that of bituminous coal, lignite cannot economically stand long distance transportation costs. Suggested alternative methods for using the field's potential energy were either a mine-mouth power plant or gasification of the coal on-site.

NOVA SCOTIA

One of the most significant developments in 1968 related to endeavours in Nova Scotia. Following a number of studies on the overall coal problems of the Maritimes the federal and provincial governments co-operated in the development of programs designed to end the type of federal financial assistance provided by transportation subventions and related assistance programs. It was recognized that the Cape Breton coal-producing area constituted a regional problem of considerable magnitude. Consequently, in 1967, the Cape Breton Development Corporation (DEVCO) was established to acquire, reorganize and manage the coal-mines and related interests of the Dominion Steel and Coal Corporation, Limited (DOSCO) and at the same time to help promote and finance development of industry on Cape Breton Island. The agreement between the federal and provincial governments also made provision for the province to assume complete responsibility for assistance to the independent coal-mines of the province. DEVCO assumed the above-mentioned responsibilities for the DOSCO mines as of March 31, 1968.

Of the ten producing collieries in Nova Scotia in 1968, DEVCO produced coal from four collieries in the Sydney coal-field. This field accounted for about 87 per cent of the province's total production. DEVCO produced 2.7 million tons in 1968 all by underground methods from coal-seams located under the sea. As indicated in Table 4, output per man-day averaged 2.6 tons for Nova Scotia mines compared to the Canadian average of 3.45 tons. In part, this reflects the difficult mining conditions experienced in the Nova Scotia mines which stretch for 4 miles under the sea. Modernization of these old, complex mines had been one of the problems facing the previous operators.

The coal-fields in Nova Scotia are of Carboniferous age and contain the oldest coal measures in Canada. The Sydney coal is high volatile bituminous which can be carbonized into coke. However, a large market for Sydney coal has been for thermal power generation in Ontario. This market soon will be discontinued but the company hopes that more coal will be used for coke making in DEVCO's own coke-oven plant to offset the more distant markets.

The corporation also continued with plans to develop a highly mechanized colliery on the Lingan property, containing a previously untouched block of coal between No. 12 and No. 26 collieries. This seam, currently mined on adjacent leases, outcrops inland but pitches under the sea as do all other seams in the Sydney area. Development of the mine is scheduled to begin in June 1969 and should be in full production in 1974. As development of Lingan progresses some of the other mines are expected to be phased out. The plan is to reduce the coal work force from the present 6,000 to about 2,000 by 1973. At the same time, overall coal output will be reduced from the present 3 million tons a year rate to an anticipated 2 million tons a year. The Lingan coal from the Harbour seam is considered relatively low in sulphur permitting it to be used in a greater proportion than other domestic coal for making metallurgical coke at DEVCO's coke-oven plant.

On the Nova Scotia mainland, the McBean Colliery in Pictou county was scheduled for closure on March 31 by its owners, Acadia Coal Company Limited, a DOSCO subsidiary, because of increasing costs and near exhaustion of its reserves. To aid the area temporarily, the federal and provincial governments, DEVCO and the Pictou County Research and Development Commission (PICORD) instituted a program enabling the mine to continue operating for a limited number of years on a reducing scale. The McBean mine became the property of PICORD under the name of Thorburn Mining Limited, and is being operated and managed by DEVCO.

The remaining five independent coal-mines in Nova Scotia continued to operate but without federal financial assistance after March 31, 1968. The provincial government assumed responsibility for these five mines as per the federal-provincial agreement for whatever financial assistance the province deemed necessary subsequent to that date. Most of the 1968 output from these mines was consigned to provincial electrical utilities.

NEW BRUNSWICK

In New Brunswick, a situation similar to Nova Scotia had existed. All mines had required federal subsidies in order to operate. Under a federal-provincial agreement, the provincial government accepted responsibility for the rationalization of the coal-mines located in the Minto area, in return for a federal grant of $19.6 million to be paid over a four-year period. New Brunswick assumed management of the mines in the Minto coal-field in March 1968 under the terms of the Grand Lake Development Act. The existing complex coal leasing system was changed and replaced by a new allocation of mining areas and a system for the allocation of markets. As provided by the agreement part of the federal grant will be used to direct new industry to the Minto area and to create stable employment opportunities.

Underground mining, which provides about 15 per cent of the total coal output from the Minto area, is in some respects unique. Because the coal has a maximum overburden of 125 feet, and the thickness of seam averages 20 inches, shafts are sunk in a pattern to allow recovery of the coal in an area of roughly 1,000 feet radius from the shaft. When the coal in one area is mined out, another shaft is sunk in a new area to develop a new mine. In 1968, the New Brunswick government undertook the development of a new 'shaft' mine which will provide employment for some 200 miners who are not able to be retrained for other work. The mine will have a life expectancy of four to five years. The two currently operating 'shaft' mines are expected to be closed by early 1969. Provincial coal production went largely to thermal electric plants and a lesser quantity to pulp and paper mills.

MARKETS AND TRADE

Use of coal in Canada has not varied much since 1958 when dieselization of the railways in Canada was essentially completed. Apparent consumption in Canada in 1968 was 26 million tons, precisely the amount consumed a decade ago, in 1958. The low point of consumption was in 1961 when natural gas together with oil were making further inroads in the residential markets and taking over most of the industrial coal markets as well. However, since that time the trend in Canadian consumption has been upwards and the 1968 apparent consumption figure is the highest in the last decade.

TABLE 5

Shipments of Canadian Coal by Operators, 1968
(short tons)

Destination	Originating Province					Canada
	Nova Scotia	New Brunswick	Saskat-chewan	Alberta	British Columbia	
Railways in Canada	12,548	2,538	116,988	3,201	1,029	136,304
Ships bunkers	933	–	–	–	–	933
Newfoundland	31,568	–	–	–	–	31,568
Prince Edward Island	18,139	–	–	–	–	18,139
Nova Scotia	1,314,987	–	–	–	–	1,314,987
New Brunswick	148,369	574,004	–	–	–	722,373
Quebec	820,205	93,751	–	54	–	914,010
Ontario	1,038,195	–	159,112	15,097	42,769	1,255,173
Manitoba	–	–	510,400	73,558	127,314	711,272
Saskatchewan	–	–	1,451,765	175,992	94	1,627,851
Alberta	–	–	–	2,673,460	161	2,673,621
British Columbia	–	–	–	142,545	331,111	473,656
Totals, Canada	3,384,944	670,293	2,238,265	3,083,907	502,478	9,879,887
United States	8,627	141,172	13,025	9,549	661	173,034
Japan	–	–	–	809,437	436,263	1,245,700
Total shipments	3,393,571	811,465	2,251,290	3,902,893	939,402	11,298,621

Source: Dominion Bureau of Statistics.

The market mix has changed substantially. Electric utilities, which consumed less than 6 per cent of total coal in 1958 used over 40 per cent in 1968. Indeed electric utilities have become Canada's largest domestic users of coal. Coke making remains a substantial market using roughly 23 per cent of all coal consumed in Canada. As indicated earlier, residential, commercial and general industrial users each use substantially less coal. Domestically, the future of coal will rely to a large extent on use in thermal electric plants and for metallurgical coke.

THERMAL POWER INDUSTRY

The chief reason for the upward trend in Canadian coal consumption relates to the increased requirements for electrical energy. A number of provinces have reached the stage where regional hydraulic resources capable of generating electrical power have been largely developed and, except for the alternative of long-range transmission, regional electrical needs must be generated by some other means. This is the case in Alberta, Saskatchewan, Ontario, and the Maritime Provinces. Hence, there has been an increasing dependence upon electricity generated from coal; indeed, the amount of coal used to generate electricity has been increasing at the rate of 15 per cent per annum over the last five years.

Approximately 40 per cent of the 26 million tons of coal consumed in Canada in 1968 was used to generate electricity. As shown in Table 6, coal used for this purpose amounted to an estimated 11,082,000 tons, compared to 9,110,000 tons in 1967 and only 1,980,000 tons in 1957. About half of the coal used for electricity generation is mined in Canada and the rest is imported from the United States. The Hydro-Electric Power Commission of Ontario, the largest individual coal consumer in Canada, currently burns about 750,000 tons of coal from Sydney, Nova Scotia and about four million tons of imported coal a year. Ontario Hydro has been purchasing Nova Scotia coal annually for the last five years but because of the discontinuance of subventions this market will be lost. Consequently, the majority of coal for electricity generation in Ontario will continue to come from eastern United States. However, with new, large, low-cost, strip mines and unit train transportation, the marketing of western Canada coal in central Canada for large consumers, such as Ontario Hydro, is a possibility. The forthcoming Canada to Japan coal movement will demonstrate whether or not the large-scale transportation of western coal to central Canada markets is economically feasible.

In Ontario, four coal-fired thermal stations were under construction or being planned in 1968. At the Lakeview station near Toronto, the last three of eight 300,000 kw units were installed in 1968. At the Lambton thermal station 14 miles east of Sarnia, initial service for the first two 500,000 kw units will begin in 1969. Two other units are scheduled for service in 1970 to complete the station. A 2 million kw coal-fired station is planned for Nanticoke on the north shore of Lake Erie by 1974. Plans were announced by Ontario Hydro for a 2 million kw plant at Bath, near Kingston for completion in 1975. It is estimated that each of these plants could use 4.4 million tons of coal a year.

TABLE 6

Coal Used by Thermal Electric Generating Stations by Provinces, 1963, 1965, 1968p
(000's short tons)

	1963	1965	1968
Nova Scotia	540	700	699
New Brunswick	107	368	264
Ontario	2,870	3,934	6,100
Manitoba	65	192	196
Saskatchewan	1,060	1,195	1,482
Alberta	570	1,311	2,341
Total, Canada	5,212	7,700	11,082

Source: Dominion Coal Board.
pPreliminary.

In the Prairies, the use of coal-fired electrical plants has been increasing. Coal-fired plants are currently operating at the mine site near Estevan, Saskatchewan and at Wabamun, Alberta. The fact that a coal-fired plant is economical in Alberta, where comparatively low cost oil and gas are available, augurs well for the future there. Indeed, the 582,000 kw Wabamun thermal power plant, about 50 miles west of Edmonton, originally began as a gas-fired operation but it was converted to use local coal. At the new Sundance thermal station, south of Lake Wabamun, work on the installation of a 300,000 kw coal-fired unit is under way. This new unit scheduled for service in 1971 will increase by 50 per cent the demand for subbituminous coal in the area. The Sundance plant is planned to have four such units in operation by 1978. The plant will use coal from an adjacent strip mine. The Boundary Dam lignite fired thermal station at Estevan, in southeastern Saskatchewan is also adding two 150,000 kw steam turbines scheduled for operation in 1969 and 1970. A 105,000 kw lignite-fired steam generator, is scheduled for completion at the Brandon, Manitoba thermal station in 1970 which will use Saskatchewan lignite.

COKE INDUSTRY

The carbonizing of coal to make metallurgical coke for the manufacture of primary iron is slowly

TABLE 7

Coke Oven and Other Carbonization Plants in Canada

Coke Plant	Battery and No. of Ovens	Oven type	Year Built	Plant Capacity (000 tpy coal)	Byproducts
The Algoma Steel Corporation, Limited, Sault Ste. Marie, Ontario	No. 5 – 86	Koppers-Becker Underjet	1943	2,700	Napthalene, light oil, gas, tar
	No. 6 – 57	Koppers-Becker Underjet	1953		
	No. 7 – 57	Wilputte Underjet	1958		
	No. 8 – 60	Wilputte Underjet	1967		
The Steel Company of Canada, Limited, Hamilton, Ontario	No. 3 – 61	Wilputte Underjet	1947	2,670	Tar, sulphate of ammonia, sodium phenolate, gas
	No. 4 – 83	Wilputte Underjet	1952		
	No. 5 – 47	Wilputte Underjet	1953		
	No. 6 – 73	Otto Underjet	1967		
Dominion Foundries and Steel, Limited, Hamilton, Ontario	No. 1 – 25	Koppers-Becker Gun Type Comb	1956	1,400	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		
Cape Breton Development Corporation, Sydney, Nova Scotia	No. 5 – 53	Koppers-Becker Underjet	1949	900	Tar, crude oil, gas
	No. 6 – 61	Koppers-Becker Underjet	1953		
Quebec Natural Gas Corporation, Ville La Salle, Quebec	No. 1 – 59	Koppers-Becker	1928	626	Tar, sulphate of ammonia, light oil, gas
	No. 2 – 15	Koppers-Becker	1947		
Husky Oil (Alberta) Ltd. Bienfait, Saskatchewan	2 units	Lurgi Carbonizing retort	1925	110	Creosote, lignite tar, lignite pitch
Shawinigan Chemicals Limited Shawinigan, Quebec	8 units	Travelling grate coking stoker	1939	200	Low-grade producer gas
The Canmore Mines, Limited Canmore, Alberta	1 unit	Vertical retort	1963	30	Crude tar, gas
Kaiser Coal Ltd. Fernie, British Columbia	3 units	Mitchell	1963	2	No byproducts
	10 units	Curran-Knowles	1939	243	(experimental) Crude tar, gas
	10 units	Curran-Knowles	1943		
	16 units	Curran-Knowles	1949		
	16 units	Curran-Knowles	1952		

increasing in Canada. Domestic iron and steel output has been increasing rapidly and under traditional circumstances there would have been a commensurate increase in coke requirements. However, the iron and steel industry has been developing new measures designed to maximize iron production from established blast furnaces. This is being accomplished by using a lower proportion of coke in the furnace burden, sufficient at least to provide the reducing environment for iron production, and using fuel oil or natural gas to provide supplemental heat to replace the lower proportion of coke in the burden. Even with such measures, pig iron output has been such that coke requirements have been increasing at an annual rate of over 7 per cent per annum since 1961.

In 1968, approximately 7.4 million tons of bituminous coal was carbonized to produce 5.3 million tons of coke. This compares to 5.9 million tons of coal used for production of 4.4 million tons of coke in 1967. Over 95 per cent of coal used to make coke in Canada was imported from the United States. The foundation of this reliance rests on two main reasons. First, the United States has been able to provide economical, high-quality, coking coals consistently without interruption. Second, the bulk of the primary iron and steel industry is located in Ontario in close proximity to high grade and readily available coking coals of the eastern United States. Logistics, therefore, have a great influence on the source of coal. The fact that Sydney, Nova Scotia iron and steel operations also use a high proportion of United States coal although coal is available locally attests to the importance of quality. The reliance that the steel industry places on United States coal may be judged from the fact that three of the four steel companies that operate blast furnaces in Canada have ownership interests in United States coal-mines.

Most of the coke produced in Canada is manufactured in standard slot-type ovens at five plants in Ontario, Nova Scotia and Quebec. The plants have annual capacities that vary from 600,000 to two million tons of coal feed. About 95 per cent of the coal used in the production of coke is processed at these five plants. With one exception, the plants are owned and operated by steel companies. The excepted plant, at Montreal, was built in an earlier era primarily to produce manufactured gas for Montreal and to supply the residential market with coke. There remains a demand for coke and byproducts because of the industrial complexes located at Montreal. Three of the four integrated steel plants completed expansion of their coke oven plants by early 1968. Two

TABLE 8

Coke – Production and Trade

	1967		1968p	
	Short Tons	$	Short Tons	$
Production*				
Coal coke				
Ontario	3,653,694	. .	4,369,120	. .
Other provinces	776,605	. .	941,642	. .
Total	4,430,299		5,310,762	
Petroleum coke	227,886	. .	226,308e	. .
Total	4,658,185		5,537,070	
Imports (all types)				
United States	935,091	18,656,000	755,718	14,933
West Germany	17,794	293,000	61,094	1,140
Total	952,885	18,949,000	816,812	16,073
Exports (all types)				
United States	83,933	1,266,000	132,047	2,018,000
Japan	–	–	20,160	177,000
Total	83,933	1,266,000	152,207	2,195,000

Source: Dominion Bureau of Statistics.

p Preliminary; e Estimated; – Nil; . . Not available.

*Practically all coke production is used internally in the iron and steel industry and is not given a value.

of these plants added taller, byproduct slot-type ovens with greater capacity. At one plant the addition of a high-oven battery was the first to be contracted for in North America. The Sydney Steel Corporation coke oven plant was purchased in 1968 by the Cape Breton Development Corporation in order to provide greater market flexibility for its coal. DEVCO's coke oven plant currently uses about 80 per cent coal from the United States with 20 per cent Sydney coal in order to produce coke of acceptable quality for the nearby steel plant. As indicated earlier DEVCO anticipates that by modifying its coal mining operations and bringing in the Lingan mine it will be able to supply a greater proportion of the coke requirements of Sydney Steel Corporation.

In North America, interest is growing toward a return of the use of non-recovery ovens since it is becoming increasingly more difficult to market byproducts due to competition from the petrochemical industry. Three such ovens have been built in the Crowsnest area of British Columbia on an experimental basis to explore the market for foundry coke in western Canada and western United States. Within Canada, uses for coke other than the primary iron industry include small amounts for foundry practice, base-metal recovery, chemical processes and domestic heating.

GOVERNMENT ASSISTANCE

Subvention payments by the federal government through the Dominion Coal Board to assist the movement of coal to markets were reduced from $35.7 million in 1967 to $12.8 million in 1968 as indicated in Table 10. This substantial reduction is related in large measure to discontinuation of subvention payments in eastern Canada. However, federal aid continued to be given in the form of underwriting annual operating losses of DEVCO's Coal Division amounting to $17 million in 1968 (nine months from April 1 to December 31). These are expected to be reduced to $15 million or less by 1974. In western Canada, the rate of federal subvention aid per ton of exported coal is being progressively reduced so that such subventions will cease on March 31, 1971. Since inception in 1928, to March 31, 1968, $317,288,873 has been paid by the federal government for subvention aid. All coal producing provinces have benefited, but the Nova Scotia coal industry received 78 per cent of this aid and is indicative of the reasoning that led to the formation of DEVCO.

The payment of subsidies provided under the Canadian Coal Equality Act were also discontinued on March 31, 1968. This Act was designed to assist the Dominion Iron Steel Limited. It provided for the payment to iron and steel producers of 49.5 cents per ton for bituminous coal mined in Canada used to produce coke for the Canadian manufacture of iron and steel.

TABLE 9

Coke – Production and Trade, 1958-68
(short tons)

	Production				Imports			Exports
	Coke	Pitch	Petroleum Coke	Total	Coke	Petroleum Coke	Total	Total
1958	3,474,985	8,155	462,797	3,945,937	305,330	300,366	605,696	145,202
1959	4,094,882	3,463	529,580	4,627,925	382,683	314,732	697,415	176,020
1960	3,872,802	3,414	534,979	4,411,195	297,707	403,391	701,098	161,190
1961	3,899,545	4,466	964,494	4,868,505	288,815	365,744	654,559	226,703
1962	4,021,774	1,899	201,985	4,225,658	247,304	338,068	585,372	157,882
1963	4,280,797	–	199,636	4,480,433	234,610	369,037	603,647	154,332
1964	4,342,982	–	206,815	4,549,797	315,763	440,607	756,370	120,740
1965	4,368,791	–	242,813	4,611,604	569,905	413,047	982,952	88,632
1966	4,426,051	–	230,119	4,656,170	584,965	499,154	1,084,119	87,615
1967	4,430,299	–	227,886	4,658,185	387,049	565,836	952,885	83,933
1968P	5,310,762	–	226,308	5,537,070	255,405	561,407	816,812	152,207

Source: Dominion Bureau of Statistics.
PPreliminary; – Nil.

TABLE 10

Coal Moved Under Subvention, 1967-68

Origin of Coal	1967 Short Tons	1967 $	1968 Short Tons	1968 $
Nova Scotia	3,415,230	29,583,325	729,648	5,224,405
New Brunswick	687,125	2,421,328	767,832	3,705,644*
Saskatchewan	269,695	186,132	185,852	132,960
Alberta and British Columbia	1,256,068	3,531,747	1,351,337	3,728,690
Total	5,628,118	35,722,532	3,034,669	12,791,699

Source: Dominion Coal Board.
*Subvention total includes $1,126,257 paid to the Province of New Brunswick in 1968.

TABLE 11

Coal Trade, Canada, 1967-68
(short tons)

	1967 Short Tons	1967 $	1968p Short Tons	1968p $
Production				
Canada, Total	11,122,935	82,759,916	10,954,780	61,097,458
Exports				
Bituminous				
St. Pierre	1,929	31,000	1,588	20,000
United States	169,361	1,727,000	172,044	1,545,000
Japan	1,167,055	13,334,000	1,273,222	14,768,000
Other countries	8	..	159	3,000
Total	1,338,353	15,092,000	1,447,013	16,336,000
Briquettes				
United States	26,914	419,000	25,363	381,000
Imports (for consumption)				
Anthracite				
United States	525,645	6,094,000	418,621	5,298,000
USSR	–	–	11,576	79,000
Total	525,645	6,094,000	430,197	5,377,000
Bituminous				
United States	15,588,545	139,064,000	16,616,548	154,740,000
Briquettes				
United States	8,487	386,000	6,062	273,000

pPreliminary; – Nil; . . Not available.

The granting of loans to the coal-mining industry under the Coal Production Assistance Act was also discontinued. This Act provided a nonrevolving fund of $10 million from which loans could be made to coal-mines anywhere in Canada to assist them in improving the efficiency of their operations through mechanization.

In 1958, the Atlantic Provinces' Power Development Act was passed to provide long-term loans for construction of thermal electric power plants and related facilities in the Atlantic provinces. This Act also provided for subvention payments on eastern Canadian coal used in electric power production in plants located in the Atlantic provinces. As the result of the rationalization of the Maritime coal industry, it is anticipated that this Act will be rescinded or modified.

TABLE 12

Supply and Demand of Coal, 1957 and 1967

	1957	1967
Supply		
Production[1]	13,189,155	11,122,935
Landed imports	19,936,933	15,812,448
Total inventory change	+1,122,544	+629,099
Total supply	32,003,544	26,306,284
Demand		
Exports	396,311	1,338,353
Domestic sales		
Electric utilities	1,981,877	9,113,373
Mining and manufacturing	10,788,954	6,732,198
Coke making	5,720,325	5,987,575
Sub total	18,491,156	21,833,146
Retail sales	6,891,857	1,349,261
Railways	4,075,096	162,537
Ships bunker	494,104	334,396
Government and institutional	245,000	176,000
Sub total	11,706,057	2,022,194
Coal mine and local use	1,149,904	597,183
Loss	228,549	254,420
Unaccounted for	31,567	260,988
Total domestic consumption	31,607,233	24,967,931
Total demand	32,003,544	26,306,284

Source: Dominion Bureau of Statistics.
[1]Production excludes amounts put on waste heap.

IMPORTS

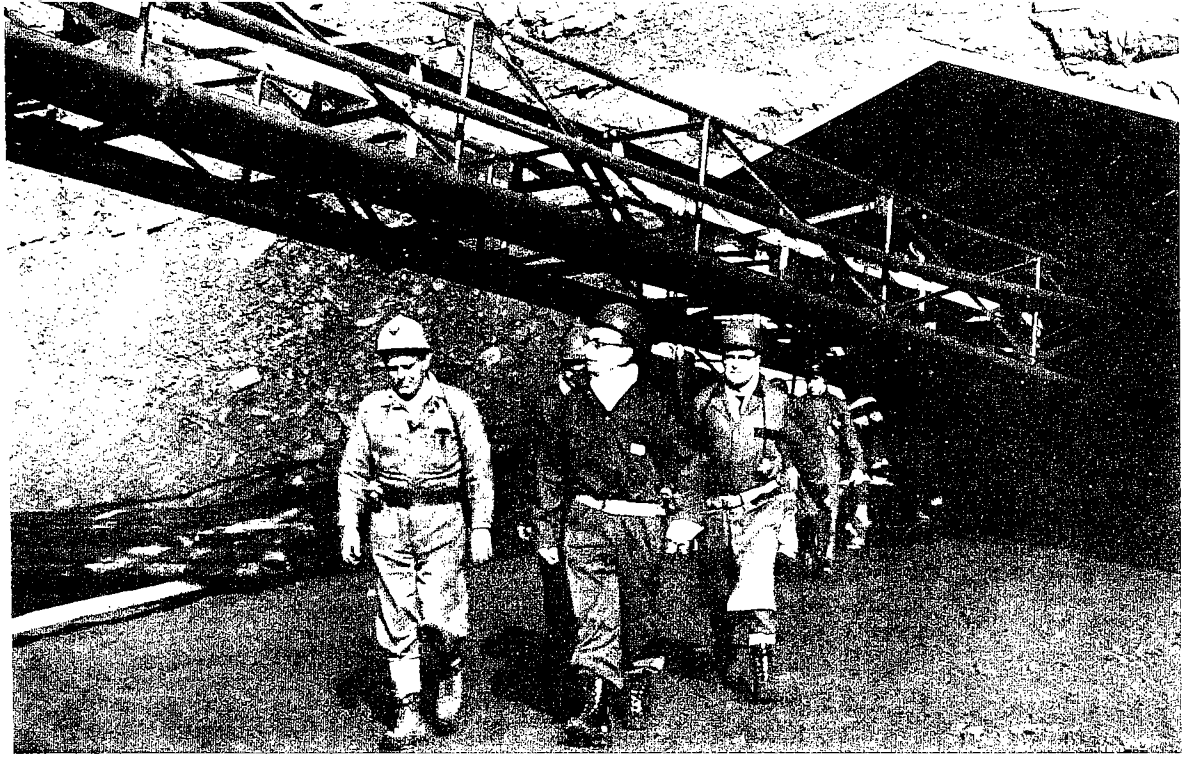
In 1968, Canada imported 17 million tons of coal all from the United States except for a small shipment of anthracite from the USSR as shown in Table 11. About 90 per cent of the imported coal went to Ontario markets with the remainder going to Quebec consumers. The larger markets for coal within Canada are Ontario and western Quebec. Ontario markets are especially dependent on coal imports, with recent increases due primarily to growth in demand for thermal electric power as discussed elsewhere. With the expansion of the metallurgical and thermal power industries in Ontario, the demand for imported coal should substantially increase in the coming years.

TARIFFS

The 50 cents per ton duty on imported bituminous coal, except for metallurgical coal which is exempt, is being reduced 10 cents per ton per year, effective January 1, 1968 until its elimination. The tariff applied almost entirely to United States coal used for thermal power generation in Ontario.

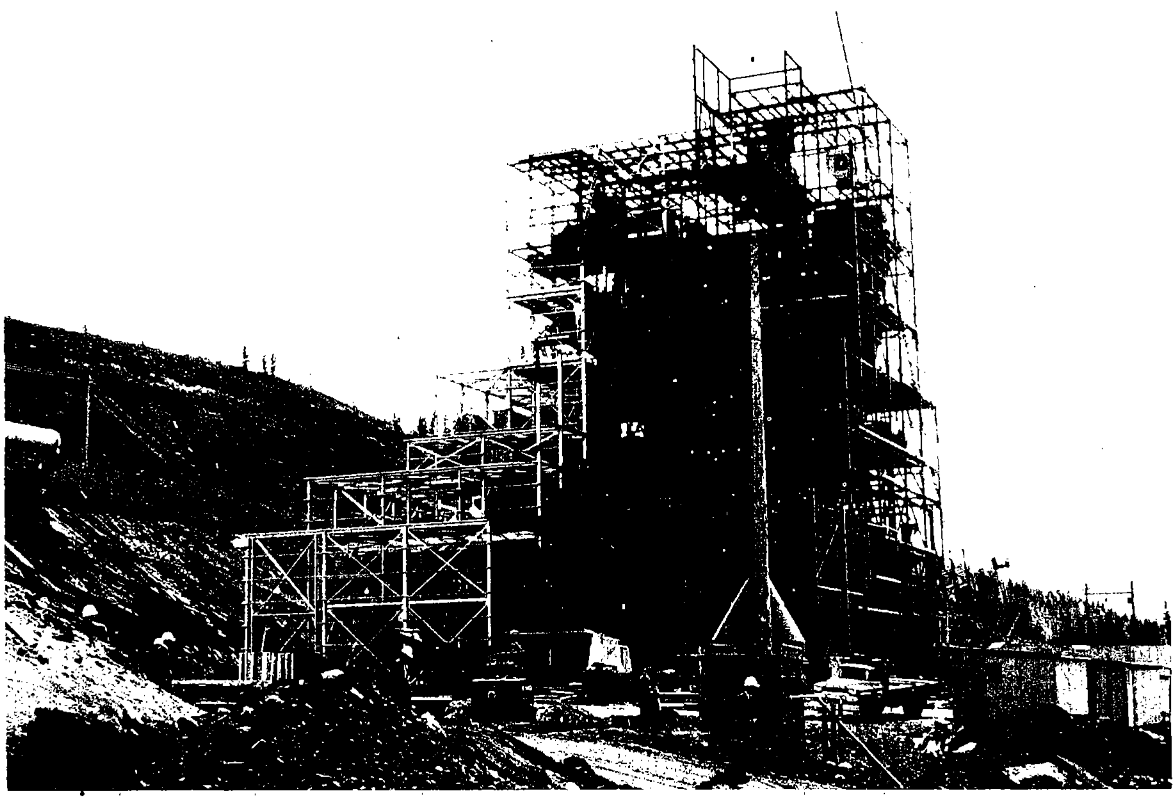
EXPORTS

Exports of coal in 1968 were 1.4 million tons having a value of $16.3 million (Table 11). Shipments were predominantly to Japan with lesser volumes being delivered to the United States, the French island of St. Pierre, and West Germany. Exports of coal to Japan in 1968 were about 9 per cent higher than in 1967 and will continue to increase in the years ahead. Export contracts, which have been announced by western Canada mines as discussed previously, indicate that by mid-1970 exports to Japan should approach 6 million long tons per annum. Negotiations that are under way suggest that exports should double from 1970 to 1975 and approach 12 million tons per annum. Indicative of the market possibilities is the letter of intent, which Kaiser Coal announced in December, for the export of an additional 6 million long tons of coal over three years, beginning in 1970. As of January 1, 1969, a total of almost 113 million tons of Canadian coal have been contracted for shipment to Japan between 1968 and 1985. At the present time, Japan imports about 32.4 million tons of coking coals annually. Canada in 1968 supplied 3.6 per cent of the Japanese coal imports with the United States supplying 43.9 per cent, Australia 37 per cent, USSR 8.5 per cent, and Poland 3.1 per cent. By the early 1970's, Canada will likely rank a fairly close third to the United States and Australia as a supplier of coking coal to Japan.



VICARY CREEK MINE, COLEMAN COLLIERIES LIMITED, Coleman, Alberta. A 36-inch conveyor belt system transports the coal to surface from underground continuous mining equipment. (Photo by EMR Staff)

COAL PREPARATION PLANT, Kaiser Resources, Limited, Elk Valley, British Columbia. When completed in early 1970 the plant will be capable of cleaning 1,400 net tone of raw coal per hour. (Photo by EMR Staff)



WORLD DEVELOPMENTS RELATED TO CANADA

As shown in Table 13, world production in 1967 for all types of coal was just over 3 billion tons representing a decrease of 117 million tons from 1966. This decrease reflects substantially the efforts of the important coal producing industry of Europe to rationalize its operation as well as the effects of the increasing competition from oil and gas in most countries. Six countries, United States, USSR, Mainland China, Britain, Poland, and West Germany, in order of output accounted for 80 per cent of the world's coal production in 1967. Approximately 60 countries reported some coal production in 1967. The following summary of selected countries is presented because of the effect on the Canadian coal industry.

AUSTRALIA

The Australian coal industry has become a chief supplier of coal to the Japanese steel industry. A total of almost 190 million tons of Australian coal have been contracted up to the end of 1968 for shipment to Japan between 1968 and 1985. The Australian producers are confident that contracts with Japan will be expanded.

Australia possesses large reserves of low-cost stripable bituminous and lignite coal. Occurrences of metallurgical coking coal, bituminous coals, and anthracites are mainly confined to two areas, the Sydney Basin of New South Wales and the Bowen Basin of Queensland. These major coal-fields are Permian in age and lie on or close to the eastern seaboard. Australia's relatively low-cost coal is a main competitor in a number of the world's markets but from Canada's viewpoint the most significant is its coal trade with Japan. In 1968 production reached 40.2 million long tons while exports were about 12.3 million tons with 12 million tons going to Japan. Significant gains in production and exports are expected in 1969.

JAPAN

Since 1957, Canada has been a small supplier to Japanese metallurgical coal market. This trade, which accounted for 6.3 per cent in 1964 has declined in the last years to something less than 4 per cent in 1968. The United States has been the principal supplier to Japan during this period but in the interim Japan has attempted to diversify its areas of supply and as a result the United States share has dropped from about 80 per cent in the late 1950's to less than half in the last four years.

The major recent inroad into the Japanese market has been by Australian coal which has become a significant supplier to Japan within the last decade and recently has accounted for roughly 40 per cent of Japanese imports.

Total coal imports in 1968 reached an all-time high of 32.4 million metric tons, an increase of almost 7 million tons or 27 per cent over 1967. Coking quality bituminous coal accounted for the greater portion of the increase to keep up with the unprecedented rise in Japanese steel production. To ensure an adequate supply of coking coal, Japanese steel producers have signed long-term contracts with the United States, Australia, Canada, the USSR, and Poland.

Annual output of Japan's coal-mines at present is about 47 million tons. However, the Japanese coal-mines with their extremely low productivity (1.5 tons per man per day) require rehabilitation subsidies and other industrial aids to keep operating. Recent plans call for a reduction in the number of mines and yearly production to be around 35 million tons by the end of 1973. At the present time, Japan can import some coal from abroad much cheaper than it can produce from its own mines.

Starting in 1970, the recent downward trend in Canada's share of Japanese coal imports should be reversed. It is generally contended that additional needs by Japan up to the mid-1970's will be required, therefore the prospects for additional sales by Canada are present.

UNITED STATES

The United States, the world's largest coal producer of bituminous and anthracite coal is also the largest coal exporter. Reserves in the United States are widely distributed and enormous in quantity. The bulk of the coking coal resources are in the eastern part of the country where they occur in thick gently sloping, easily minable seams. Estimated coal production for all types of coal in 1968 was 556 million tons, valued at more than $2.75 billion. Bituminous coal constituted the largest type of coal mined with relatively smaller amounts of lignite and Pennsylvania anthracite also produced.

In 1968, United States coal exports reached a record high of 51 million tons, compared to 50 million tons exported in 1967. The principal foreign markets for United States coal are Europe, Canada and Japan. Canada is the largest single foreign consumer taking 34 per cent of the total United States exported coal. In 1968 Japan received 31 per cent of United States exports. Increases in exports to Canada and Japan have offset recent losses in coal exports to Europe where greater reliance on recent major gas discoveries and increased oil imports have tended to reduce imports as well as production.

TABLE 13

World Coal Production
(thousand short tons)

Country	1963	1964	1965	1966	1967p
North America	490,098	517,884	540,776	560,567	577,066
South America	8,722	9,528	9,822	10,043	10,521
Europe	1,842,918	1,897,678	1,893,694	1,869,780	1,843,770
Africa	51,357	54,520	59,061	58,124	59,150
Asia	478,253	495,884	518,055	555,798	443,763
Oceania	51,582	55,230	61,318	64,640	67,721
World					
Lignite (estimate)	783,941	819,930	812,750	807,593	803,000
Bituminous and Anthracite (by subtraction)	2,138,989	2,210,794	2,269,976	2,311,359	2,198,991
Total, all grades*	2,922,930	3,030,724	3,082,726	3,118,952	3,001,991

Source: United States Bureau of Mines.

p Preliminary.

*Totals are of listed figures only; no undisclosed data included.

Indicative of the ideally situated coal reserves and modern mining methods employed in the United States is the average productivity which reached 19.17 tons per man day in 1967. Due to rising demands by electric utilities coal consumption is forecast to increase 12.8 per cent to 644 million tons in 1973 over the expected 1969 consumption of 571 million tons. In order to meet this demand about 75 new bituminous coal mines were reported to be preparing for production at the end of 1968.

OTHER COUNTRIES

The other countries that ship coking coal to Japan are the Soviet Union, Poland and China.

The USSR is the world's largest coal producer of all types of coal (including lignite). In 1967, production was estimated at 656 million tons, 490 million tons of bituminous and anthracite and 166 million tons of lignite. Production has increased steadily since 1959 to meet the coal requirements of the thermal electric and metallurgical industries. Coal exports have also increased substantially from 6.6 million tons in 1958 to almost 25 million tons in 1967. In the USSR as in other large coal-mining countries, improvements in mechanization and automation have permitted a significant increase in productivity. However there still exists a number of technically obsolete underground mines in the USSR, which accounts for the low productivity of between 1.9 and 5.5 metric tons per man-shift.

Poland is fifth in the world in terms of coal production. In contrast to the declining coal industry in other European countries, Poland's coal-mines are being expanded. Japan began importing Polish coal in 1966, and in 1967 signed a contract covering deliveries totalling 3 million tons over a three-year period beginning in 1968. Following this, it is anticipated long term contracts will be made. A complicating factor is the closure of the Suez Canal which increases laid down cost to Japan. The present quantities delivered to Japan are roughly equal to Canada's and constitute about 3 per cent of total Japanese imports.

Little factual information is available on the Chinese coal industry but China is one of the largest coal-producing countries in the world. This can be substantiated because of its relative paucity of domestic and imported oil and gas and the country evidently relies on coal for the vast bulk of its energy requirements. In fact it has a large gasoline producing industry based on coal. In any event, although the Japanese are prepared to sign contracts for Chinese coking coal, comparatively small volumes have been contracted for and these on a more or less annual basis.

Cobalt

G.P. WIGLE*

Canadian cobalt production in 1968 was 3.9 million pounds valued at $8.5 million which compares with 3.6 million pounds valued at $7.3 million in 1967. Non-communist world production of cobalt in 1968 was an estimated 18,625 tons compared with 18,695 tons produced in 1967.

United States General Services Administration's sale of 2,763 tons of cobalt from stockpile surplus during the year was an influence on the cobalt market. United States consumption was an estimated 5,015 tons in 1968. Stockpile sales of cobalt in 1967 were 3,000 tons and domestic consumption was 6,988 tons. Producer's prices of cobalt metal remained at levels established in January, 1967 and supplies were adequate. Sherritt Gordon Mines, Limited reduced the premium prices for its cobalt powder and briquettes in order to make them competitive with the prices of granules. The General Services Administration plans to continue sales of about one million pounds of cobalt during each quarter of 1968.

CANADIAN PRODUCTION

The International Nickel Company of Canada, Limited (Inco) produces cobalt oxide and electrolytic cobalt at its refining operations at Port Colborne, Ontario. Cobalt oxide and cobalt salts are produced at Inco's refinery at Clydach, Wales, from cobalt oxide shipped from Canada. Deliveries of 1.79 million pounds of cobalt from all Inco operations, including the production at Clydach, were reported for 1968. International Nickel produces cobalt oxide at its Thompson, Manitoba nickel refinery.

Falconbridge Nickel Mines, Limited produces cobalt at its refinery at Kristiansand, Norway, from nickel-copper matte shipped from Canada.

Sherritt Gordon Mines, Limited, produced 893,609 pounds of cobalt in 1968 compared with 764,073 pounds in 1967. Cobalt is recovered as a byproduct of its nickel-refining operations at Fort Saskatchewan, Alberta. The refinery treats nickel-copper concentrates from the company's Lynn Lake mine in Manitoba, nickel and cobalt-bearing materials on a toll basis, and alloy grindings containing cobalt.

Cobalt is recovered as a byproduct of the smelting and refining of complex silver-cobalt concentrates from the mines of the Cobalt and Gowganda areas of Ontario. The Cobalt Refinery Division of Kam-Kotia Mines Limited did not operate the cobalt-oxide part of its plant in 1968. The speiss (cobalt, nickel, silver) byproduct of its smelting and refining of silver-cobalt concentrates was shipped to Belgium for treatment and sale. The refinery's output of refined silver from material handled on a custom and toll basis for domestic and foreign customers was a record 12.8 million ounces. Alterations and development studies were carried out in the cobalt section of the plant and it is expected that by 1970 the modified plant will have sufficient capacity to process all the byproduct speiss and produce cobalt and nickel oxides.

*Mineral Resources Branch.

TABLE 1

Canada, Cobalt Production, Trade and Consumption 1967-68

	1967		1968p	
	Pounds	$	Pounds	$
Production[1] (all forms):				
Quebec	34,801	75,170	12,000e	25,920
Ontario	2,929,470	5,967,044	3,244,656	6,955,640
Manitoba	639,502	1,310,219	722,000	1,562,000
Total	3,603,773	7,352,433	3,978,656	8,543,560
Exports				
Cobalt metal				
United States	673,961	1,359,000	811,960	1,655,000
Belgium and Luxembourg	695,360	761,000	269,772	510,000
Britain	27,410	61,000	100,797	213,000
France	22,009	51,000	17,600	40,000
Mexico	10,800	23,000	4,500	10,000
Argentina	10,667	23,000	3,682	8,000
Other countries	58,352	184,000	2,598	9,000
Total	1,498,559	2,462,000	1,210,909	2,445,000
Cobalt oxides and salts[2]				
Britain	1,918,400	3,250,000	1,581,800	2,695,000
United States	16,100	30,000	64,700	128,000
Total	1,934,500	3,280,000	1,646,500	2,823,000
Consumption[3]				
Cobalt contained in:				
Cobalt metal	229,091	..	274,334	..
Cobalt oxide	49,275	..	53,848	..
Cobalt salts	14,720	..	29,916	..
Total	293,086	..	358,098	..

Source: Dominion Bureau of Statistics.
[1] Production (cobalt content) from domestic ores as cobalt metal and cobalt in alloys, oxides and salts. Includes the cobalt content of Inco and Falconbridge shipments to overseas refineries. [2] Gross weight. [3] As reported by consumers.
pPreliminary; eEstimated; .. Not available.

WORLD PRODUCTION

Non-communist world production of cobalt in 1968 estimated at 18,625 tons (cobalt content) was little changed from 1967. Some additional production is expected in 1969 from recently completed, 2,000 ton-a-year, cobalt refining facilities in Finland, and from new nickel-producing operations in Canada. The Democratic Republic of the Congo (Kinshasa), the world's largest producer, recovers its cobalt as a byproduct of copper refining operations and is expected to increase its current production of 11,000 to 12,000 tons of cobalt a year to about 17,500 tons a year by 1970 or 1971.

Cobalt is recovered in small quantities in the United States as a byproduct of a magnetite ore that contains cobalt-bearing pyrite, and from some zinc plant residues. United States refiners and processors produce a range of cobalt products from duty-free imported ores, concentrates and unwrought cobalt metal.

CONSUMPTION AND USES

Consumption of cobalt in Canada in 1968 was 358,098 pounds, 77 per cent of it as cobalt metal, 15 per cent in cobalt oxide, and 8 per cent in cobalt salts.

TABLE 2

Canadian Cobalt Production, Trade and Consumption, 1959-68
(pounds)

	Production[1] (all forms)	Exports			Imports		
		Cobalt Metal	Cobalt Alloys[3]	Cobalt Oxide and Salts[3]	Cobalt Ores	Cobalt Oxides[3]	Consumption[2]
1959	3,150,027	680,323	3,280	1,100,734	–	24,716	250,046
1960	3,568,811	844,293	1,938	1,175,206	–	20,227	252,050
1961	3,182,897	603,931	..	1,521,000	–	28,364	390,091
1962	3,481,922	542,565	..	1,629,900	–	40,936	383,442
1963	3,024,965	739,227	..	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
1968p	3,978,656	1,210,909	..	1,646,500	..	..	358,098

Source: Dominion Bureau of Statistics.
[1] Production from domestic ores of cobalt metal and cobalt contained in alloys, oxides and salts. 1967 and 1968 production includes the cobalt content of Inco and Falconbridge shipments to overseas refineries, but prior years exclude Inco shipments to Britain. [2] Total consumption, cobalt content of metal, oxides and salts. [3] Gross weight.
pPreliminary; – Nil; .. Not available.

The cobalt content of United States imports of cobalt in 1968 was an estimated 4,372 tons compared with 4,108 tons in 1967. Consumption was 5,015 tons compared with 6,988 tons in 1967. The United States General Services Administration supplemented supplies by the sale of 2,763 tons of cobalt from stockpile in 1968.

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

Cobalt is widely dispersed in the rocks of the earth's crust, constituting about 0.0023 per cent as 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%) and about one-third that of copper (.0070%). Non-communist world production of cobalt is about 18,000 tons a year while annual production of lead is approximately 2.3 million tons and of copper 4.7 million. 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.

TABLE 3

Non-Communist World Production of Cobalt
(short tons of contained cobalt)

	1966	1967	1968[e]
Congo (Kinshasa)	12,453	10,709	11,642
Morocco	2,198	2,130	1,685
Canada	1,756	1,802[r]	1,989[p]
Zambia	1,670	1,604	1,481
Finland	1,500	1,350	557
Other countries	1,117	1,100	1,271
Total	20,694	18,695	18,625

Sources: U.S. Bureau of Mines Minerals Yearbook, 1967; 1968 figures, Cobalt Information Center, Battelle Memorial Institute, Columbus, Ohio; and company reports.

[p]Preliminary; [e]Estimated; [r]Revised.

The important types of cobalt minerals are sulphides, arsenides, and oxides. The principal sulphide minerals are linneaite (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 of the oxide minerals are erythrite, or cobalt bloom ($3CoOAs_2$ $8H_2O$), heterogenite (CoO_2 (Co_2O_3 $6H_2O$), and asbolite (CoO_2 MnO_2 $4H_2O$). The cobalt minerals are seldom found in sufficient quantity to be mined for cobalt alone.

TABLE 4

United States Consumption of Cobalt by Use, 1967-68
(thousand pounds cobalt content)

	1967		1968[p]	
		Per cent		Per cent
Metallic:				
High-speed steel	374	2.7	321	2.9
Other tool and alloy steel	806	5.8	750	6.8
Permanent-magnet alloy	2,486	17.8	2,594	23.5
Cutting and wear-resisting materials	324	2.3	**	
High-temperature high-strength materials	3,447	24.7	2,053	18.6
Alloy hard-facing rods and materials	864	6.2	362	3.3
Cemented carbides	486	3.5	498	4.5
Nonferrous alloys	177	1.3		
Other*	2,241	16.0	1,841	16.7
Total	11,205	80.3	8,419	76.3
Nonmetallic exclusive of salts and driers:				
Ground-coat frit	286	2.0	204	1.8
Pigments	204	1.5	210	1.9
Other materials	689	4.9	535	4.9
	1,179	8.4	949	8.6
Salts and driers: lacquers, varnishes, paints, inks, pigments, enamels, feeds, electroplating, etc.	1,592	11.3	1,662	15.1
Grand total	13,796	100.0	11,030	100.0

Sources: U.S. Bureau of Mines, Minerals Yearbook, 1967 and U.S. Mineral Industry Surveys, January to December, 1968.

*Includes unspecified end uses. **Figures withheld, included in Other.

[p]Preliminary.

PRICES

Prices of cobalt in the United States according to *Metals Week,* December 30, 1968 were:

Cobalt metal per lb f.o.b. New York, effective Jan. 4, 1967,	
shot 99%+	
less than 100-lb lots	U.S. $1.92
100-lb lots	1.87
500-lb lots (f.o.b. N.Y., Chicago)	1.85
Powder	
99% +, 300 mesh	
100 lb lots	2.39
extra fine, 125-kilo drums	2.89
Fines	
95-96%, per lb contained	
Regular	2.25
300 mesh	2.27
Briquettes, 10 ton lots, per lb contained	1.88
Cobalt oxide	
per lb, 250 lb, contained	
Ceramic, delivered, 3¢ more west of Mississippi	
70-71%	1.81
72½-73½%	1.86
Metallurgical	
f.o.b. N.Y.	
75-76% (per lb contained)	2.35

TARIFFS

	British Preferential	Most Favoured Nation	General
CANADA			
Cobalt ore	free	free	free
Cobalt metal; ingots, pigs, sheets, plates, strips, rods, tubes			
On and after Jan. 1, 1968	free	8%	25%
〃 〃 Jan. 1, 1969	free	6%	25%
Cobalt metal in bars	free	10%	25%
Cobalt oxide	free	10%	10%

UNITED STATES	
Cobalt ore	free
Cobalt metal, unwrought	free
Cobalt alloys, unwrought	
On and after Jan. 1, 1968	16%
〃 〃 Jan. 1, 1969	14%
Cobalt metal, wrought	
On and after Jan. 1, 1968	16%
〃 〃 Jan. 1, 1969	14%
Cobalt oxide and cobalt sulphate	
On and after Jan. 1, 1968	1.3¢ per lb
〃 〃 Jan. 1, 1969	1.2¢ per lb
Cobalt compounds, other	
On and after Jan. 1, 1968	10.5%
〃 〃 Jan. 1, 1969	9.5%
Cobalt linoleate	
On and after Jan. 1, 1968	6.5¢ per lb
〃 〃 Jan. 1, 1969	5.8¢ per lb

Sources: The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa.
Tariff Schedules of the United States Annotated (1969), TC Publication 272.

Columbium (Niobium) and Tantalum

G.P. WIGLE*

Canada's commercial production of columbium began in 1961 when St. Lawrence Columbium and Metals Corporation started mining pyrochlore at its properties near Oka, Quebec. Production in 1968 was 2.1 million pounds of columbium pentoxide (Cb_2O_5) in pyrochlore concentrates. St. Lawrence is the only Canadian producer of columbium and is one of only two mines in the world that produce columbium-pyrochlore concentrates as a primary product, the other, larger operation, is in Brazil. A large part of St. Lawrence production was exported to Europe and the United States.

The columbium market was in a situation of oversupply during the latter part of 1967 and the first half of 1968. Columbium prices declined and major producers reduced output. A moderate recovery in prices took place in the latter part of 1968.

Commercial tantalum production was scheduled to start in 1969 at the Bernic Lake, Manitoba, mine of Tantalum Mining Corporation of Canada Limited.

CANADIAN DEVELOPMENTS AND PRODUCTION

Tantalum Mining Corporation of Canada Limited expected to start tantalum production at Bernic Lake, Manitoba, during the first half of 1969. Construction of the 500-ton-a-day crushing and concentrating plant, and mine preparation work were approaching completion at the end of 1968. Plant capacity provides for the annual production of about 500,000 pounds of tantalum pentoxide (Ta_2O_5) in a 50 per cent tantalite concentrate. Ore reserves were estimated at approximately 2 million tons averaging 0.23 per cent Ta_2O_5.

Consolidated Morrison Explorations Limited, Imperial Oil Enterprises Ltd., and associated companies completed a 76 foot shaft and 98 feet of crosscutting, to provide a 250 ton sample for metallurgical testing, on their large columbium-pyrochlore property in the James Bay Lowlands area about 31 miles south of Moosonee, Ontario. Crystals of columbium-bearing pyrochlore occur in a carbonatite host rock. The pyrochlore is reported to be very low in tantalum and contains only negligible amounts of uranium and thorium. It was reported that drilling totalling some 42,000 feet had indicated about 80,000 tons per vertical foot averaging 0.52 per cent columbium pentoxide (Cb_2O_5).

St. Lawrence Columbium and Metals Corporation reduced production in 1968 because of temporary oversupply in the market for columbium. The mill treated 360,194 tons of ore and recovered 2,005,989 pounds of Cb_2O_5 in the 12 months ending September 30, 1968 compared with 369,642 tons milled and 2,368,225 pounds of Cb_2O_5 recovered in the same period of 1967. The company planned to increase production by about 40 per cent in 1969. Drill-hole indicated ore reserves above the 1,000 foot level and within 1,000 feet of the shaft were reported to be 2.5 million tons grading 0.48 per cent Cb_2O_5.

Masterloy Products Limited, near Ottawa, Ontario, produced 547,000 pounds of ferrocolumbium containing approximately 60 per cent columbium.

* Mineral Resources Branch.

TABLE 1

Canada, Columbium (Niobium) and Tantalum Production,
Trade and Consumption, 1967-68

	1967		1968P	
	Pounds	$	Pounds	$
Production (Cb_2O_5 content of products shipped)	2,159,557	2,404,475	2,118,000	2,393,340
Imports[1] from United States				
Columbium and columbium alloys, wrought and unwrought, waste and scrap	185	21,024	375	24,128
Tantalum and tantalum alloys, wrought and unwrought, waste and scrap	1,245	195,086	1,972	117,240
Tantalum and tantalum alloy powder	1,155	33,527	1,830	59,443
Exports[2] to United States				
Columbium ore and concentrates	890,884	481,792	295,333	156,970
Consumption by the steel industry				
Ferrocolumbium and ferro-tantalum-columbium (Cb and Ta-Cb content)	78,000	..	..	..

Source: Dominion Bureau of Statistics.

[1] From U.S. Department of Commerce, Exports of Domestic and Foreign Merchandise, Report FT 410. Values in U.S. Currency. [2] From United States Department of Commerce, Imports of Merchandise for Consumption, Report FT 125, Values in U.S. Currency.

P Preliminary; . . Not available.

WORLD PRODUCTION

Non-communist world production of columbium and tantalum concentrates in 1968 amounted to about 11,500 tons, of which 10,885 tons were columbium concentrates of columbite or pyrochlore and 615 tons were tantalum concentrates (tantalite).

Brazil became the leading producer of columbium concentrates in 1966 and maintained that position through 1967 and 1968. Production in 1968 was 6.6 million pounds of Cb_2O_5 in pyrochlore concentrates. Ferrocolumbium production began in Brazil in 1964 and amounted to 582 tons in 1967. United States 1968 imports of columbium concentrates from Brazil increased to 55 per cent of the total imported compared with 50 per cent in 1967; US imports of columbium from Canada dropped to 8 per cent of the total imported compared with 13 per cent in 1967.

Nigeria had been the perennial leader in the production of columbium which began there about 1933. In contrast to the more recent producers of columbium-bearing pyrochlore, its columbite concentrates are a co-product of tin mining.

Columbium and/or tantalum concentrates are also produced in eight or more countries other than the principal producers listed in Table 2 but their combined annual production is less than 10 per cent of the world total.

CONSUMPTION AND USE

Canada's consumption of columbium and tantalum in the form of ferroalloys increased sharply to approximately 78,000 pounds in 1967 compared with 40,000 pounds in 1966. The market for this material is growing in such applications as the manufacture of oil and gas transmission pipe.

The United States is the largest consumer of columbium and tantalum. The major part of its wholly imported supply is used to make ferrocolumbium and ferrotantalum-columbium. The steel industry uses these ferroalloys in the making of alloy and stainless steels, high-temperature alloys, nickel-base alloys, and 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 the use of 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 use of columbium in industries in the United States is approximately: steel – 78 per cent, nonferrous alloys – 21 per cent; and of tantalum: electronics – 65 per cent, chemical equipment – 25 per

TABLE 2

Non-Communist World Production of
Columbium and Tantalum Concentrates
(short tons)

	1967		1968[e]	
	Columbium	Tantalum	Columbium	Tantalum
Brazil, pyrochlore	5,089	–	5,750	–
columbite-tantalite	113	226	. .	235
Nigeria	2,154	12	2,300	15
Canada, pyrochlore	2,204	–	2,000	–
Mozambique	–	181	–	185
Republic of the Congo (Kinshasa)	33	156	45	170
Malaysia	93	–	100	–
Other countries	570	12	690	10
TOTAL	10,256	587	10,885	615

Source: U.S. Bureau of Mines, Commodity Data Summaries, January 1969; and company reports.
[e] Estimated; – Nil; . . Not available.

cent, nonferrous alloys – 5 per cent, carbides – 5 per cent.[1]

The principal Canadian suppliers of ferro-columbium are Union Carbide Canada Limited; Metallurg (Canada) Ltd.; and Masterloy Products Limited. The Macro Division of Kennametal Inc., Port Coquitlam, B.C. makes high-purity tantalum carbides and columbium carbides.

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 Crucible Steel of Canada Ltd.

PRINCIPAL MINERALS AND 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 co-products 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 mineral pyrochlore recovered 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, the James Bay, Ontario, property of Consolidated Morrison Explorations Limited, the Manitou Islands deposits of Nova Beaucage Mines Limited near North Bay, and the Lackner Lake, Ontario, property of Multi-Minerals Limited. There are 30 or more known carbonatite occurrences in Ontario, several in Quebec and Labrador and possibly 4 in British Columbia.

Columbite and tantalite have the theoretical compositions (Fe Mn)O.Cb_2O_5 and (Fe Mn)O.Ta_2O_5. They are closely related minerals and frequently associated in ore occurrences. The two minerals vary in composition from the nearly pure columbite (FeO.Cb_2O_5) containing 82.7 per cent Cb_2O_5, to nearly pure tantalite (FeO.Ta_2O_5) containing 86.1 per cent Ta_2O_5. The iron and manganese content varies widely and tin and 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, scheduled for production of tantalite concentrates in 1969, 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 pin-point 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, 13.2 per cent of tin oxide (SnO_2).

[1] U.S. Bureau of Mines, Commodity Data Summaries, January 1969.

PRICES

The published spot prices of Canadian pyrochlore, f.o.b. the mine, declined from U.S. \$1.02-\$1.07 a pound of contained Cb_2O_5 in December, 1967 to U.S. 90¢-93¢ in April 1968 and recovered to US 92¢-98¢ in December, 1968. Average selling prices during 1966 and 1967 in Canadian currency were \$1.22 and \$1.13 a pound of contained Cb_2O_5 respectively.

The price of tantalum – mineral concentrates, 60 per cent basis, c.i.f. U.S. ports was about U.S. \$8.00 a pound of Ta_2O_5, during the latter part of 1968.

The following quotations are from *Metals Week* of December 30, 1968, in U.S. Currency:

	U.S. Currency
Columbium ore	
Columbite, per lb Cb_2O_5, 10 to 1 ratio, c.i.f. U.S. ports, spot	80 to 89¢
Pyrochlore, per lb Cb_2O_5 Canadian, f.o.b. mine or mill	92 to 98¢
Brazilian, f.o.b. shipping point, spot, one-year contracts	95.5¢
Ferrocolumbium per lb Cb, ton lots, f.o.b. shipping point	
Low-alloy, standard grades	\$2.45-2.60
High-purity grades	\$3.82-4.50

Columbium metal per lb 99.5 – 99.8%, depending on size of lot

	Powder, Roundel	Ingot
Reactor	\$12-23	\$17.50–28
Metallurgical	\$11-22	\$16–27

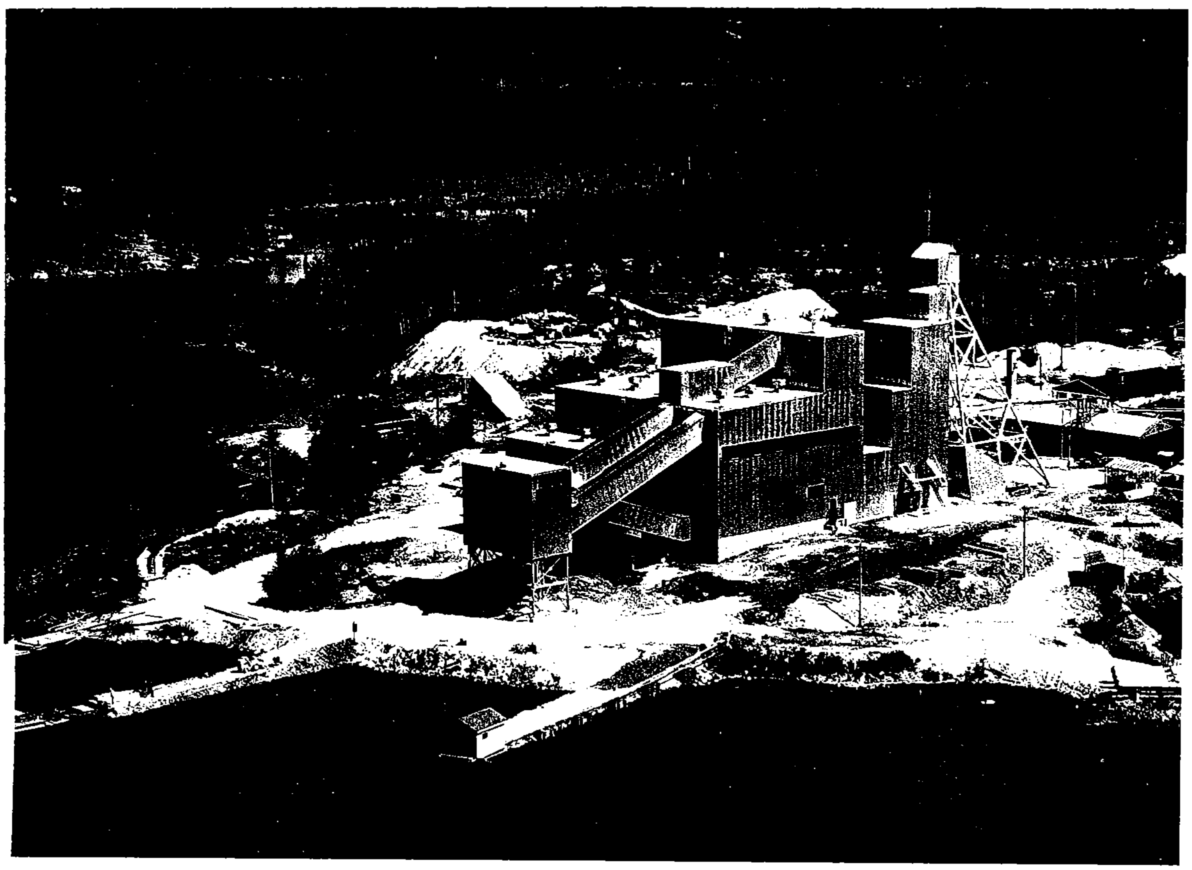
Tantalum metal	
powder, per lb, f.o.b. shipping point, depending on size of lot	\$32-46
Mill products, depending on grade	
Sheet	\$36-60
Rod	\$40-52

TARIFFS

	British Preferential	Most Favoured Nation	General
CANADA			
Columbium and tantalum ores and concentrates	free	free	free
Ferrocolumbium, ferro-tantalum and ferro-tantalum-columbium	free	5%	5%
Columbium metal and tantalum metal, in lumps, powders, ingots or blocks			
On and after Jan. 1, 1968	free	13%	25%
On and after Jan. 1, 1969	free	11%	25%
UNITED STATES			
Columbium and tantalum ores and concentrates		free	
Columbium, unwrought (other than alloys), waste and scrap (duty on scrap suspended to June 3/69)			
On and after Jan. 1, 1968		9%	
On and after Jan. 1, 1969		8%	
Columbium, unwrought alloys			
On and after Jan. 1, 1968		13%	
On and after Jan. 1, 1969		12%	
Columbium, wrought			
On and after Jan. 1, 1968		16%	
On and after Jan. 1, 1969		14%	

Tantalum, unwrought, other than alloys; waste and scrap (duty on scrap suspended to June 30/69)	
On and after Jan. 1, 1968	9%
On and after Jan. 1, 1969	8%
Tantalum, unwrought alloys	
On and after Jan. 1, 1968	13%
On and after Jan. 1, 1969	12%
Tantalum wrought	
On and after Jan. 1, 1968	16%
On and after Jan. 1, 1969	14%

TANTALUM MINING CORPORATION OF CANADA LIMITED, Bernic Lake, Manitoba. Air view of mine, mill and concentrator. (Photo by Hunter)



Copper

A.F. KILLIN*

The industry-wide strike that had idled the United States copper industry since July 1967 did not end until April 1968. After the strike settlement, production recovered rapidly in the United States but the increased supply of copper was matched by a similar increase in consumer demand. Inventories that were depleted during the strike have not been replenished and the copper markets are very sensitive to supply interruptions. Non-communist world mine production according to World Metal Statistics was 4,722.4 thousand tons in 1968, 256.7 thousand tons more than in 1967. Refined copper consumption in 1968 at 6,995.7 thousand tons was 281.6 thousand tons more than in 1967, according to the same source. The difference between mine production and consumption was supplied from reprocessed scrap.

Mine production in Canada rose to 620,071 tons, 6,758 tons more than in 1967. Increased production in Ontario, Manitoba and the Yukon and Northwest Territories was partially offset by decreases in Quebec, British Columbia, Saskatchewan and Newfoundland. Refined production at 524,956 tons was 25,110 tons higher than in 1967. The world demand for copper, and copper products, brought about a resurgence of exports of semi-fabricated products (sheet, tube, wire, etc.) and, in turn, a rise in domestic consumption of refined copper from 224,400 tons in 1967 to 253,200 tons in 1968.

Exports of copper in ores and concentrates increased sharply from 128,976 tons in 1967 to 161,835 tons in 1968. Refined exports, however, increased by only 500 tons to 276,619 tons.

Exploration for and development of new deposits continued across Canada with particular emphasis on the large, low-grade bulk deposits in British Columbia.

CANADIAN DEVELOPMENTS

The Canadian copper industry can be divided structurally into mining and milling; smelting; refining; and fabricating. Mine production in 1968 was obtained in eight provinces and the Yukon and Northwest Territories; smelter production in Quebec, Ontario and Manitoba and refinery production in Quebec and Ontario. The principal fabricating plants were in Quebec, Ontario and British Columbia but satellite plants were operating in other provinces.

The major producing provinces were: Ontario (288,484 tons); Quebec (156,113 tons); British Columbia (82,424 tons); Manitoba (33,275 tons); Saskatchewan (22,734 tons); and Newfoundland (21,860 tons). Lesser production was obtained from New Brunswick, Yukon Territory, Northwest Territories and Nova Scotia.

Details of individual mine production and development are given in Table 3. The following résumé outlines the production and developments by provinces.

*Mineral Resources Branch.

TABLE 1

Canada, Copper Production, Trade and Consumption, 1967-68

	1967		1968P	
	Short Tons	$	Short Tons	$
Production[1]				
Ontario	276,146	261,814,899	288,484	277,522,347
Quebec	166,385	158,298,866	156,113	150,180,715
British Columbia	86,319	82,112,961	82,424	79,292,405
Manitoba	29,560	28,123,194	33,275	32,011,363
Saskatchewan	22,974	21,858,046	22,734	21,870,600
Newfoundland	21,965	20,897,555	21,860	21,029,782
New Brunswick	5,786	5,504,985	8,060	7,754,122
Yukon	3,584	3,409,779	5,982	5,755,550
Northwest Territories	566	538,077	1,048	946,108
Nova Scotia	28	26,910	91	87,584
Total	613,313	582,585,272	620,071	596,450,576
Refined	499,846		524,956	
Exports				
Copper in ores, concentrates and matte				
Japan	93,632	82,666,000	112,610	110,437,000
Norway	15,217	16,922,000	22,944	18,355,000
United States	7,168	6,070,000	9,690	6,784,000
Sweden	4,925	4,117,000	6,730	5,718,000
Belgium and Luxembourg	1,093	672,000	3,795	2,901,000
Spain	2,303	2,204,000	1,910	1,643,000
Britain	1,544	1,430,000	1,709	1,486,000
East Germany	–	–	790	728,000
Other countries	3,094	2,794,000	1,657	1,300,000
Total	128,976	116,875,000	161,835	149,352,000
Copper in slag, skimmings and sludge				
United States	429	385,000	2,387	344,000
Belgium and Luxembourg	113	40,000	50	22,000
Spain	–	–	27	19,000
Other countries	2	1,000	–	–
Total	544	426,000	2,464	385,000
Copper scrap (gross weight)				
West Germany	4,337	3,884,000	15,699	15,247,000
Belgium and Luxembourg	2,150	1,572,000	14,462	13,073,000
United States	9,383	8,776,000	10,812	10,413,000
Spain	3,810	3,525,000	10,378	10,675,000
Italy	–	–	2,577	2,296,000
Yugoslavia	367	283,000	2,449	2,432,000
Hungary	176	165,000	2,426	2,379,000
Japan	9,772	8,603,000	2,255	2,113,000
Other countries	1,166	981,000	4,125	3,979,000
Total	31,161	27,789,000	65,183	62,607,000

TABLE 1 (Cont'd)

	1967		1968P	
	Short Tons	$	Short Tons	$
Brass and bronze scrap (gross weight)				
West Germany	1,405	949,000	8,422	6,541,000
Japan	10,894	7,303,000	6,664	4,545,000
Belgium and Luxembourg	792	568,000	3,856	3,161,000
United States	1,871	1,200,000	3,342	2,314,000
Italy	242	165,000	2,592	1,659,000
Other countries	1,477	1,092,000	2,700	2,101,000
Total	16,681	11,277,000	27,576	20,321,000
Copper alloy scrap, n.e.s. (gross weight)				
Belgium and Luxembourg	168	116,000	436	340,000
Japan	1,271	859,000	278	165,000
United States	142	56,000	140	80,000
Other countries	86	66,000	162	93,000
Total	1,667	1,097,000	1,016	678,000
Copper refinery shapes				
United States	147,101	139,325,000	134,248,	133,250,000
Britain	94,006	100,261,000	103,395	114,979,000
West Germany	7,773	7,710,000	10,705	11,983,000
France	11,059	11,462,000	10,550	10,768,000
Japan	4,798	4,742,000	5,772	5,689,000
Netherlands	1,257	1,247,000	2,953	2,646,000
India	2,952	3,030,000	2,286	2,269,000
Switzerland	1,748	1,863,000	1,448	1,653,000
Italy	1,548	1,492,000	1,338	1,394,000
Brazil	1,498	1,492,000	1,134	1,010,000
Belgium and Luxembourg	19	15,000	963	874,000
Portugal	785	750,000	650	778,000
Other countries	1,375	1,422,000	1,177	1,305,000
Total	275,919	274,811,000	276,619	288,598,000
Copper bars, rods and shapes, n.e.s.				
United States	2,852	3,313,000	5,854	7,588,000
Norway	1,978	2,188,000	4,077	4,568,000
Britain	1,638	1,798,000	3,978	4,579,000
Pakistan	2,518	2,862,000	2,879	3,009,000
Switzerland	2,831	2,901,000	2,846	3,183,000
Denmark	1,769	1,981,000	2,538	3,016,000
Yugoslavia	661	653,000	997	1,036,000
West Germany	560	550,000	910	917,000
Netherlands	312	338,000	803	785,000
Other countries	2,954	3,190,000	2,692	3,013,000
Total	18,073	19,774,000	27,574	31,694,000

TABLE 1 (Cont'd)

	1967		1968p	
	Short Tons	$	Short Tons	$
Copper plates, sheet, strip and flat products				
United States	5,993	7,881,000	10,367	14,202,000
Venezuela	305	449,000	403	589,000
Britain	65	100,000	254	322,000
New Zealand	152	238,000	93	140,000
Colombia	–	–	50	69,000
Other countries	93	133,000	39	61,000
Total	6,608	8,801,000	11,206	15,383,000
Copper pipe and tubing				
United States	6,118	8,392,000	10,021	14,835,000
New Zealand	1,345	2,256,000	670	1,127,000
Puerto Rico	734	1,097,000	657	1,034,000
Britain	355	548,000	584	908,000
Venezuela	343	533,000	342	548,000
Philippines	355	593,000	242	379,000
Other countries	1,149	1,807,000	1,134	1,762,000
Total	10,399	15,226,000	13,650	20,593,000
Copper wire and cable, not insulated				
United States	1,517	1,819,000	3,990	4,827,000
Pakistan	523	616,000	404	482,000
Iran	–	–	229	307,000
Argentina	–	–	150	179,000
Portugal	50	70,000	150	171,000
Other countries	173	232,000	651	766,000
Total	2,263	2,737,000	5,574	6,732,000
Copper alloy refinery shapes, sections and flat products				
United States	8,035	9,219,000	7,573	8,624,000
Japan	29	26,000	693	566,000
Spain	–	–	333	502,000
Britain	74	106,000	301	387,000
Venezuela	185	253,000	192	248,000
Belgium and Luxembourg	132	171,000	73	101,000
Other countries	632	731,000	176	234,000
Total	9,087	10,506,000	9,341	10,662,000
Copper alloy pipe and tubing				
United States	1,218	1,935,000	746	1,189,000
Spain	307	446,000	162	252,000
Puerto Rico	79	128,000	105	168,000
Japan	25	57,000	104	228,000
India	247	371,000	80	359,000
Other countries	419	628,000	255	434,000
Total	2,295	3,565,000	1,452	2,630,000

TABLE 1 (Cont'd)

	1967		1968p	
	Short Tons	$	Short Tons	$
Copper alloy wire and cable, not insulated				
United States	335	569,000	245	391,000
Britain	7	13,000	37	132,000
Australia	13	25,000	6	12,000
Other countries	5	8,000	5	22,000
Total	360	615,000	293	557,000
Copper alloy fabricated materials, n.e.s.				
United States	332	570,000	507	1,236,000
Yugoslavia	–	–	295	26,000
Belgium and Luxembourg	13	8,000	26	6,000
Other countries	58	110,000	58	100,000
Total	403	688,000	886	1,368,000
Wire and cable insulated[2]				
United States	6,633	9,435,000	7,073	9,529,000
Turkey	–	–	1,268	1,066,000
Puerto Rico	593	1,130,000	874	1,738,000
Philippines	1,765	2,776,000	829	1,565,000
Britain	111	203,000	523	611,000
Pakistan	102	116,000	328	442,000
Bahamas	412	527,000	266	354,000
Nigeria	206	324,000	243	377,000
Panama	158	113,000	230	286,000
Ghana	11	20,000	228	165,000
Jamaica	295	449,000	200	331,000
Other countries	2,230	3,328,000	1,802	2,407,000
Total	12,516	18,421,000	13,864	18,871,000
Imports				
Copper in ores, concentrates and scrap	24,178	20,205,000	51,151	47,772,000
Copper refinery shapes	5,310	5,225,000	5,824	5,640,000
Copper bars, rods and shapes (sections) n.e.s.	451	464,000	631	648,000
Copper plates, sheet, strip and flat products	199	297,000	499	723,000
Copper pipe and tubing	892	1,223,000	589	979,000
Copper wire and cable except insulated	214	332,000	89	204,000
Copper alloy scrap (gross weight)	10,643	7,173,000	17,547	13,573,000
Copper powder[3]	400	536,000	339	555,000
Copper alloy, refinery shapes, rods and sections	1,941	2,468,000	2,379	2,928,000
Brass plates, sheet and flat products[3]	2,154	2,426,000	1,762	2,132,000
Copper alloy plates, sheet, strip and flat products	514	1,028,000	393	901,000
Copper alloy pipe and tubing	904	1,700,000	1,263	2,496,000
Copper alloy wire and cable, except insulated	1,032	1,922,000	705	1,317,000
Copper alloy castings[3]	264	629,000	202	447,000

TABLE 1 (Cont'd)

	1967		1968P	
	Short Tons	$	Short Tons	$
Imports (Cont'd)				
Copper and alloy fabricated materials, n.e.s.	629	1,455,000	582	1,103,000
Insulated wire and cable	. .	12,472,000	. .	10,916,000
Copper oxides and hydroxides	194	228,000	160	204,000
Copper sulphate	465	187,000	416	180,000
Consumption[4]				
Refined	224,400		253,200	

Source: Dominion Bureau of Statistics.

[1]Blister copper plus recoverable copper in matte and concentrate exported. [2]Includes also small quantities of non-copper wire and cable, insulated. [3]Not available as separate class prior to 1967. [4]Producers' domestic shipments.

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

NEWFOUNDLAND

There are five producing mines in Newfoundland with total output in 1968 of 21,800 tons of copper, 105 tons less than in 1967. The Newfoundland mines are small to medium sized with mill capacities varying from 1,250 tons of ore a day to 2,000 tons a day. With the exception of the Buchans mine, all concentrates were shipped to the Murdochville, Quebec smelter of Gaspé Copper Mines, Limited. There has been increased interest in the exploration for new copper deposits in the last two years and several large companies including Noranda Mines Limited, McIntyre Porcupine Mines Limited and British Newfoundland Exploration Limited had exploration parties in the field.

NOVA SCOTIA

Copper produced in Nova Scotia is contained in the lead-copper concentrates produced at the Walton mine of Dresser Industries, Inc.

NEW BRUNSWICK

Copper production increased in New Brunswick despite the closure of Cominco Ltd.'s Wedge mine. Heath Steele Mines Limited converted a portion of its mill from the treatment of Wedge ore to a circuit suitable for the treatment of its own ore. The mill capacity will be expanded. Nigadoo River Mines Limited completed its first full year of production.

More than sixty companies and individuals were exploring in New Brunswick for mineral deposits. The main areas of interest were: Tobique River to Chaleur Bay; Woodstock-Bathurst; and St. Stephen-Moncton. Metallurgical test work and production feasibility studies were being carried out on the Caribou deposit of Anaconda American Brass Limited, the Upsalquitch River deposit of Restigouche Mining Corporation, Ltd. and the Northumberland County property of Chester Mines Limited. Renewed exploration activity was recorded in the St. Stephen-Mount Pleasant area in southwestern New Brunswick.

QUEBEC

Quebec is Canada's second largest copper-producing province with output in 1968 of 156,113 tons. Production is obtained from five distinct copper districts: Gaspé Peninsula (two producers, two developing); Eastern Townships (two producers, one developing); Chibougamau-Chapais (ten producers, one developing); Mattagami-Joutel (six producers); Noranda-Val d'Or (five producers, one developing. Two small copper-nickel producers, one at Belleterre and one at Malartic, ceased operations during the year. Loss of production from these mines coupled with decreased production from mines in the Mattagami and Noranda districts reduced Quebec's total output by 10,272 tons in 1968. Copper smelters were operated at Noranda and Murdochville, and a copper refinery at Montreal East.

TABLE 2

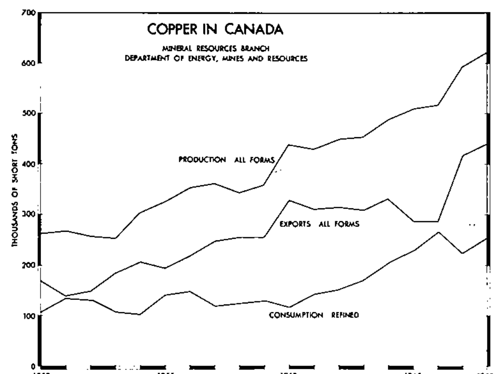
Canada, Copper Production, Trade and Consumption, 1959-68
(short tons)

	Production		Exports			Imports	Consumption[2]
	All Forms[1]	Refined	In Ore and Matte	Refined	Total	Refined	Refined
1959	395,269	365,366	32,070	222,437	254,507	105	129,973
1960	439,262	417,029	47,633	278,066	325,699	25	117,637
1961	439,088	406,359	42,894	266,247	309,141	3	141,808
1962	457,385	382,868r	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	433,004r	94,888	190,691	285,579	10,492	262,557
1967	613,313	499,846	128,976	275,919	404,895	5,310	224,400
1968p	620,071	524,956	161,835	276,619	438,454	5,824	253,200

Source: Dominion Bureau of Statistics.

[1] Blister copper plus recoverable copper in matte and concentrate exported. [2] Producers' domestic shipments, refined copper.

p Preliminary; r Revised.



ONTARIO

The International Nickel Company of Canada, Limited with 12 operating mines, four mills, two smelters and a copper refinery in the Sudbury district, was Ontario's and Canada's largest copper producer. The company is developing six more nickel-copper mines in the province and was building one new mill. The second largest Canadian producer was Ecstall Mining Limited's Kidd Creek mine near Timmins. The major Ontario copper producing areas are: Sudbury (20 mines, eight mills, three smelters, one refinery); Timmins (four mines, four mills); and Manitouwadge (four mines, two mills).

Production in 1968 was 288,454 tons, 12,338 tons more than in 1967 and the highest output of all of the provinces.

MANITOBA

Hudson Bay Mining and Smelting Co., Limited, operating two mines, a mill and a smelter near Flin Flon and three mines in the Snow Lake area, was Manitoba's largest and Canada's third largest copper producer. The company was developing two new mines in the Snow Lake region and had discovered a new orebody in the same area. Sherritt Gordon Mines, Limited at Lynn Lake was Manitoba's second largest copper producer and was developing a new deposit at Fox Lake for production in 1970.

Production in 1968 rose to 33,274 tons from the 29,560 tons produced in 1967.

SASKATCHEWAN

Two mines in the La Ronge area and the Saskatchewan portion of Hudson Bay's Flin Flon deposit accounted for the 22,734 tons of copper produced in this province in 1968. Hudson Bay was preparing the Flexar mine for production in 1969.

BRITISH COLUMBIA

Copper production declined slightly in 1968 to 82,424 tons, 3,895 tons less than in 1967. Copper mines were widely distributed in the province but the Highland Valley – Merritt district continued as the major producing area. Bethlehem Copper Corporation Ltd. in the Highland Valley and Craigmont Mines Limited near Merritt together accounted for 49 per cent of the province's copper output in 1968.

TABLE 3

Producing Companies, 1968

Company and Location	Mill or Mine Capacity (tons ore/day)	Ore Produced 1968 (1967) (short tons)	Grade (%) Copper	Zinc	Nickel	Developments
Newfoundland						
American Smelting and Refining Company (Buchans Unit), Buchans	1,250	378,000 (378,000)	1.11	12.83	–	Routine exploration and development.
Atlantic Coast Copper Corporation Limited, Little Bay	1,200	346,289 (341,322)	0.96	–	–	Surface geophysical surveys and diamond drilling. Ore reserves declining with possibility of closure in 1969.
British Newfoundland Exploration Limited, Whalesback mine, Springdale	2,000	725,867 (658,285)	0.98	–	–	Routine exploration and development.
Consolidated Rambler Mines Limited, Baie Verte East mine	1,500	361,853 (236,910)	1.25	–	–	Routine mining. Surface and underground exploration for extensions to known orebodies and for new orebodies.
First Maritime Mining Corporation Limited Gullbridge mine	2,000	598,429 (461,745)	1.02	–	–	Damming and draining of lake over the orebody to allow mining to the surface. Surface and underground exploration for new ore.
Nova Scotia						
Dresser Minerals, Division of Dresser Industries, Inc., Walton	125	49,786 (50,330)	0.40	0.26	–	Shaft deepened in 1968. Exploration for ore extensions at depth planned for 1969.
New Brunswick						
Brunswick Mining and Smelting Corporation Limited, Bathurst						
No. 6 mine	2,500	984,280 (867,373)	0.35	5.66	–	Routine open-pit mining. Waste rock delivered to the No. 12 mine for use as backfill.
No. 12 mine	4,500	1,724,465 (1,669,075)	0.27	8.56	–	Accelerated mine development. Installation of crusher at the 2,950-foot level and completion of orepass and development raises for mining below the 1,500-foot level.

TABLE 3 (Cont'd)

Company and Location	Mill or Mine Capacity (tons ore/day)	Ore Produced 1968 (1967) (short tons)	Grade (%)			Developments
			Copper	Zinc	Nickel	
Cominco Ltd., Wedge mine, Bathurst	750 (ore trucked to Heath Steele mill)	91,041 (257,019)	. .	–	–	Mine closed in April.
Heath Steele Mines Limited, Bathurst-Newcastle	1,600	391,363 (308,866)	1.19	4.89	–	Conversion of mill to treat own ore. Shaft sinking and development of ore on lower levels.
Nigadoo River Mines Limited, Robertville	1,000	284,867 (22,630)	0.32	2.44	–	Mill tune-up on stockpiled development ore. Underground development and stope preparation.
Quebec						
Bell Allard Mines Limited, Matagami	. . ore trucked to Orchan mill	98,037 (-)	1.72	10.16	–	Open-pit mining started April 1. Exploration by surface diamond drilling.
Campbell Chibougamau Mines Ltd. (Main, Cedar Bay and Henderson mines) Chibougamau	3,500 (mills Grandroy ore)	739,270 (980,536)	1.65	–	–	Mine struck from June until September. Continued exploration and development at Henderson, Cedar Bay and Kokko Creek mines. Reassessment of Main mine ore reserves.
Cupra Mines Ltd. Stratford Centre	1,500 (mills Solbec ore)	225,702 (308,347)	2.81	3.75	–	Routine mining of known ore reserves. Exploration of new ore zone by drifting and diamond drilling.
Gaspé Copper Mines, Limited, Murdochville	11,000	3,933,388 (2,763,085)	0.99	–	–	Copper Mountain open-pit mine started production in January 1968. Mill and crushing plant expansion completed.
Grandroy Mines Limited, Chibougamau	700 (trucked to Campbell mill)	117,637 (156,593)	1.22	–	–	Open-pit mining ceased in May. Exploration for more ore by diamond drilling.
Icon Syndicate, Chibougamau	600 (ore trucked to Merrill Island mill)	192,269 (82,129)	3.25	–	–	Continued open-pit and underground mining.

TABLE 3 (Cont'd)

Company and Location	Mill or Mine Capacity (tons ore/day)	Ore Produced 1968 (1967) (short tons)	Grade (%) Copper	Zinc	Nickel	Developments
Joutel Copper Mines Limited, Joutel	700 (ore trucked to Mines de Poirier mill)	242,457 (186,786)	2.55	–	–	Routine mining and development. Geophysical surveying and surface diamond drilling for more ore.
Lake Dufault Mines, Limited, Noranda	1,300	415,009 (492,938)	2.03	3.94	–	Development of C zone for mining. Shaft sinking 3½ miles south of present shaft to develop and explore new ore zone. Planned depth 9,100 feet. Diamond drilling from surface.
Lorraine Mining Company Limited, Belleterre	400	113,693 (192,532)	0.59	–	0.32	Mining ceased August 17 when ore reserves were exhausted.
Manitou-Barvue Mines Limited, Val d'Or	1,300	285,160 (294,640)	0.82	–	–	Copper ore reserves expected to be depleted by mid-1969. New zinc-silver orebody being explored and developed.
		181,250 (181,350)	–	2.21	–	
Mattagami Lake Mines Limited, Matagami	3,850	1,363,705 (1,414,000)	0.58	10.00	–	Development for mining of the No. 1 and No. 2 orebodies. Exploration for new ore including exploration of a low-grade nickel-copper occurrences north of the No. 1 orebody.
Marbridge Mines Limited, Malartic	300	54,918 (79,201)	. .	–	1.45	Ore reserves depleted, mine closed.
New Hosco Mines Limited, Matagami	900 (ore trucked to Orchan mill)	327,715 (331,228)	1.07	2.50	–	Routine exploration and development.
Noranda Mines Limited, Noranda	3,200	773,765 (855,534)	1.89	–	–	Routine exploration and development.
Normetal Mines Limited, (formerly Normetal Mining Corporation, Limited), Normetal	1,000	358,557 (348,440)	1.48	7.33	–	Routine mining of remaining ore reserves.
Opemiska Copper Mines (Quebec) Limited, Chapais	2,000	744,466 (737,272)	2.84	–	–	Developing Perry mine between 3,300- and 2,000-foot horizons. Developing Robitaille mine.

TABLE 3 (Cont'd)

Company and Location	Mill or Mine Capacity (tons ore/day)	Ore Produced 1968 (1967) (short tons)	Grade (%) Copper	Zinc	Nickel	Developments
Orchan Mines Limited, Matagami	1,900 (mills ore from New Hosco)	269,084 (375,135)	1.19	10.62	–	Routine mining. Development and exploration of new ore zone west of present workings.
The Patino Mining Corporation, Copper Rand Mines Division (Machin Point, Jaculet, Portage, and Copper Cliff mines), Chibougamau	2,000	708,134 (680,379)	1.99	–	–	Shaft deepening at the Machin Point and Copper Cliff mines. Exploration and development of all producing mines. Exploration of Bateman Bay claims from Jaculet workings.
Quemont Mines Limited (formerly Quemont Mining Corporation, Limited), Noranda	2,300	429,309 (443,774)	0.83	2.09	–	Routine mining of remaining ore reserves.
Rio Algom Mines Limited, Mines de Poirier mine, Joutel	2,500 (mills ore from Joutel)	567,000 (631,000)	1.50	2.10	–	Shaft deepening to 2,850 feet completed. Ore and waste passes being driven. Development of copper ore for mining.
Solbec Copper Mines, Ltd., Stratford Centre	400 (ore milled at Cupra)	262,076 (75,310)	1.30	4.59	–	Routine mining of remaining ore reserves.
Ontario						
Canadian Jamieson Mines Limited, Timmins	400	165,526 (. .)	2.86	4.49	–	Routine mining and development on the upper levels. Exploration drifting and diamond drilling on the fifth level.
Consolidated Canadian Faraday Limited, Werner Lake Division, Gordon Lake	750	207,417 (214,536)	0.50	–	1.05	Routine exploration and development Mill being enlarged to 1,200 tpd to accommodate ore from the Maskwa mine in Manitoba.
Copperfields Mining Corporation Limited, Temagami	200	50,321 (. .)	4.38	–	–	Shaft deepening and installation of skip hoisting. Exploration of ore zone on 1,775- and 1,975- foot levels. Surface diamond drilling for new orebodies.
Ecstall Mining Limited (Texas Gulf Sulphur Company), Kidd Creek mine, Timmins	9,000	3,614,860 (3,039,219)	1.57	9.55	–	Continued open-pit mining. Plans being developed for underground mining.

TABLE 3 (Cont'd)

Company and Location	Mill or Mine Capacity (tons ore/day)	Ore Produced 1968 (1967) (short tons)	Grade (%)			Developments
			Copper	Zinc	Nickel	
Falconbridge Nickel Mines, Limited, (Falconbridge, East, Hardy, Boundary, Onaping, Fecunis Lake, Longvac South, Strathcona), Falconbridge	3,000 (Falconbridge) 1,500 (Hardy) 2,400 (Fecunis) 6,000 (Strathcona)	3,086,399 (2,093,507)	0.80	–	1.40	Routine mining and exploration. Longvac South and Strathcona mines started production. Shaft deepening at the Onaping mine. Smelter expanded to treat concentrates from Strathcona mill.
The International Nickel Company of Canada, Limited (Frood, Stobie, Creighton, Garson, Levack, Murray, Crean Hill, MacLennan, Copper Cliff North and Totten mines, Clarabelle and Crean Hill open pits), Copper Cliff	30,000 (Copper Cliff) 12,000 (Creighton) 6,000 (Levack) 22,500 (Frood-Stobie)	20,808,500 (16,953,760)	. .	–	. .	Continued development of five new mines in the Sudbury district and a mine at Lake Shebandowan. Development and increased use of mechanized mining. Building new nickel refinery at Copper Cliff.
Kam-Kotia Mines Limited, Timmins	2,500	669,400 (679,677)	1.37	3.37	–	Completion of mill expansion, installation of new hoist and underground jaw crusher. Continued exploration for new ore and development of known ore.
Kidd Copper Mines Limited, Aer Nickel mine, Worthington	1,000	(. .)	(. .)	–	(. .)	Development and mining of known reserves. Exploration for more ore by drifting and diamond drilling.
McIntyre Porcupine Mines Limited, Schumacher	2,000	635,000 (728,590)	0.80	–	–	Continued mining and exploration of the copper ore zone including exploration on the Westfield Minerals property.
Munro Copper Mines Limited, Matheson	600	. . (. .)	. .	–	–	Operations ceased in April. Exploration by diamond drilling started in September.
Noranda Mines Limited, Geco Division, Manitouwadge	4,000	1,495,369 (1,461,000)	2.18	4.67	–	Routine exploration and development. Surface drilling of property planned.
North Canadian Enterprises Limited, Coppercorp mine, Point Mamainse	500	142,986 (. .)	1.66	–	–	Development of known ore. Exploration for ore extensions by drifting and diamond drilling.

TABLE 3 (Cont'd)

Company and Location	Mill or Mine Capacity (tons ore/day)	Ore Produced 1968 (1967) (short tons)	Grade (%)			Developments
			Copper	Zinc	Nickel	
Rio Algom Mines Limited, Pronto Division, Spragge	750	258,823 (242,530)	1.93	–	–	Incline driven below 21st level to reach additional ore. Orebody fully developed and mine on a terminal production program. Operations expected to end early in 1970.
Tribag Mining Co., Limited, Batchawana Bay	400	157,787 (100,326)	1.82	–	–	Development of West Breccia zone to augment production from present orebody. Exploration of newly discovered copper orebody and continued exploration for more ore.
Upper Beaver Mines Limited, Dobie	150 (ore to Upper Canada Mines Limited)	62,085 (61,826)	1.63	–	–	Routine exploration and development.
Willecho Mines Limited, Manitouwadge	1,000 (ore to Willroy mill)	346,444 (338,437)	0.44	3.43	–	Conveyor installation completed on lower levels. Development of lower section for mining.
Willroy Mines Limited, Manitouwadge	1,500 (mills Willecho ore)	174,336 (165,053)	0.96	2.10	–	Exploration for new ore by drifting, crosscutting and diamond drilling. Exploration of adjoining properties by drifting and diamond drilling. Routine exploration and development of known ore.
Manitoba						
Hudson Bay Mining and Smelting Co., Limited, (Flin Flon, Chisel Lake, Stall Lake, Osborne Lake, and Schist Lake mines) Flin Flon	6,000	1,610,000 (1,588,216)	2.80	5.00	–	Osborne Lake mine started production in July. New orebody discovered 10 miles north of Snow Lake.
Sherritt Gordon Mines, Limited, Lynn Lake	3,500	1,276,517 (1,071,490)	. .	–	. .	Routine exploration and development of known ore zones.

TABLE 3 (Cont'd)

Company and Location	Mill or Mine Capacity (tons ore/day)	Ore Produced 1968 (1967) (short tons)	Grade (%) Copper	Zinc	Nickel	Developments
Saskatchewan						
Hudson Bay Mining and Smelting Co., Limited, Flin Flon mine		See Manitoba				Exploration and development of known reserves. Orebody straddles the Manitoba-Saskatchewan boundary.
Rio Algom Mines Limited, Anglo-Rouyn mine, Waden Bay	900	279,797 (309,123)	2.1	–	–	Changeover from blast-hole stoping to cut-and-fill mining has reduced dilution. Exploration has maintained ore reserves.
Western Nuclear Mines, Ltd., Hanson Lake	350	60,789 (41,898)	0.48	10.89	–	Routine mining of remaining ore reserves. Mine expected to close in 1969.
British Columbia						
The Anaconda Company (Canada) Ltd., Britannia Division, Britannia Beach	3,000	. .	. .	. .	–	Shaft sinking below 4100-main-haulage-level to develop new 040 ore zone.
Bethlehem Copper Corporation Ltd., Highland Valley	14,000	5,080,664 (3,948,134)	0.58	–	–	Completion of mill expansion to 14,000 tons of ore a day. Preparation of Huestis zone for mining in 1969.
Cominco Ltd., Coast Copper mine, Benson Lake, V.I.	750	241,500 (290,524)	1.22	–	–	Routine development of known ore. Exploration by drifting and diamond drilling for new orebodies.
Craigmont Mines Limited, Merritt	5,000	1,763,123 (2,010,232)	0.97	–	–	All ore was supplied from underground mining and stockpiled material from the open pit. Exploration for new ore on surface and underground.
Falconbridge Nickel Mines, Limited, Wesfrob mine, Tasu Harbour, Q.C.I.	10,000	1,570,626 (. .)	0.74	–	–	Routine open-pit mining. Diamond drilling to establish ore reserves for underground mining in 1975.
Giant Mascot Mines Limited, Hope	1,300	338,340 (333,546)	0.23	–	0.68	Continued exploration on surface and underground has discovered new orebodies and extended known reserves. Exploration and development continuing.
The Granby Mining Company Limited, Granisle Copper mine, Babine Lake	5,000	2,230,210 (1,943,656)	0.68	–	–	Routine open-pit mining.

TABLE 3 (Cont'd)

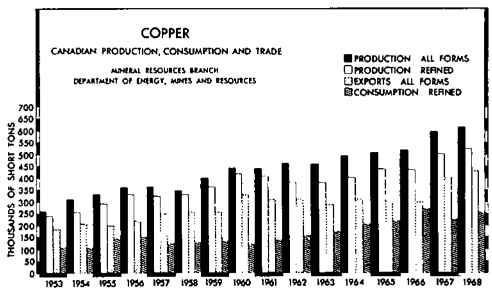
Company and Location	Mill or Mine Capacity (tons ore/day)	Ore Produced 1968 (1967) (short tons)	Grade (%)			Developments
			Copper	Zinc	Nickel	
The Granby Mining Company, Limited, Phoenix Copper Division, Greenwood	2,000	698,796 (713,513)	0.74	–	–	Routine open-pit mining. Preparation for mill expansion to 2,400 tpd in 1969.
Western Mines Limited, Buttle Lake, V.I.	750	330,223 (293,276)	1.89	9.26	–	Continued open-pit mining. Experimental cut-and-fill stoping. Exploration for more ore underground and on surface.
Yukon Territory						
New Imperial Mines Ltd., Whitehorse	2,500	732,095 (453,056)	1.03	–	–	Open-pit mining in the Little Chief and Arctic Chief pits. Extensive exploration for more ore by geophysical, geochemical and geological surveying and by diamond drilling.

Source: Company reports.
. .Not available; –Nil.

In addition to the nine mines operating in British Columbia in 1968, two large mines were being developed to production and a number of large, low-grade deposits were under extensive exploration and testing. A high level of exploration for new deposits was maintained.

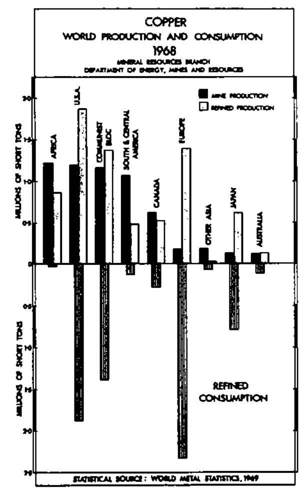
YUKON TERRITORY

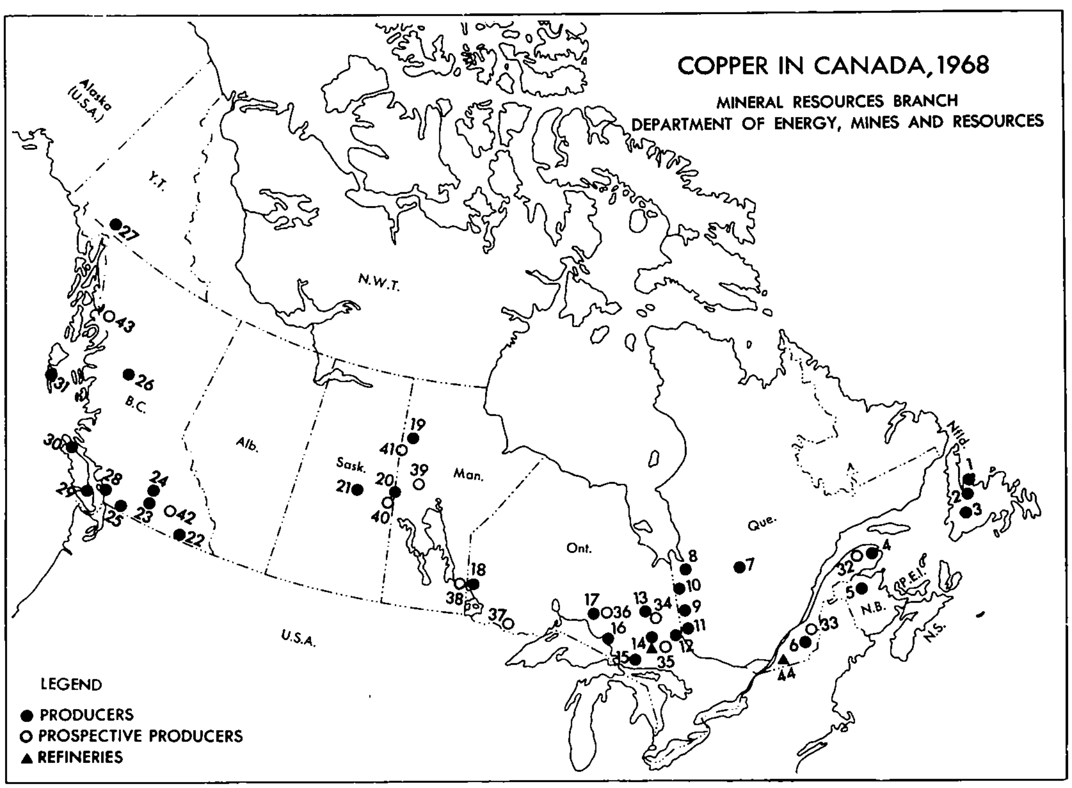
New Imperial Mines Ltd. near Whitehorse accounted for the 5,982 tons of copper produced in the Yukon in 1968.



SMELTERS AND REFINERIES

Salient statistics on Canada's six copper smelters and two refineries are given in Tables 5 and 6. The International Nickel Company announced the construction of a nickel refinery at Copper Cliff to use the pressure-carbonyl metallurgical system. Copper will be an important byproduct of this refinery.





PRODUCERS

(numbers refer to numbers on map)

1. Atlantic Coast Copper Corp. Ltd.
   British Newfoundland Expl. Ltd. (Whalesback Pond)
   Consolidated Rambler Mines Ltd.
2. First Maritime Mining Corp. Ltd. (Gullbridge)
3. American Smelting and Refining Co. (Buchans unit)
4. Gaspé Copper Mines, Ltd.
5. Brunswick Mining and Smelting Corp. Ltd. (No. 6 and No. 12)
   Cominco Ltd. (Wedge)
   Heath Steele Mines Ltd.
   Nigadoo River Mines Ltd.
6. Cupra Mines Ltd.
   Solbec Copper Mines, Ltd.
7. Campbell Chibougamau Mines Ltd. (3 mines)
   Opemiska Copper Mines (Quebec) Ltd.
   The Patino Mining Corp., Copper Rand Mines Division (4 mines)
   Grandroy Mines Ltd.
   Icon Syndicate
8. Mattagami Lake Mines Ltd.
   New Hosco Mines Ltd.
   Orchan Mines Ltd.
   Rio Algom Mines Ltd. –(Mines de Poirier)
   Joutel Copper Mines Ltd.
   Bell Allard Mines Ltd.
9. Lake Dufault Mines, Ltd.
   Manitou-Barvue Mines Ltd.
   Noranda Mines Ltd.
   Quemont Mines Ltd.
   Marbridge Mines Ltd.
10. Normetal Mines Ltd.
11. Lorraine Mining Co. Ltd.
12. Copperfields Mining Corp. Ltd. (Temagami)
13. Kam-Kotia Mines Ltd.
    McIntyre Porcupine Mines Ltd.
    Canadian Jamieson Mines Ltd.
    Ecstall Mining Limited
    Upper Beaver Mines Ltd.
    Munro Copper Mines Ltd.
14. Falconbridge Nickel Mines, Ltd. (8 mines, 1 smelter)
    The International Nickel Company of Canada, Ltd. (12 mines, 2 smelters, 1 refinery)
    Kidd Copper Mines Ltd. (Aer nickel)
15. Rio Algom Mines Ltd. (Pronto Division)
16. North Canadian Enterprises Ltd. (Coppercorp)
    Tribag Mining Co., Ltd.
17. Noranda Mines Ltd. (Geco Division)
    Willecho Mines Ltd.
    Willroy Mines Ltd.
18. Consolidated Canadian Faraday Ltd.
19. Sherritt Gordon Mines, Ltd.
20. Hudson Bay Mining and Smelting Co., Ltd. (5 mines, 1 smelter)
21. Rio Algom Mines Limited (Anglo-Rouyn mine)
    Western Nuclear Mines, Ltd.
22. The Granby Mining Company Ltd. (Phoenix Division)
23. Craigmont Mines Ltd.
24. Bethlehem Copper Corp. Ltd.
25. Giant Mascot Mines Ltd.
26. The Granby Mining Co. Ltd. (Granisle)
27. New Imperial Mines Ltd.
28. The Anaconda Company (Canada) Ltd. (Britannia Division)
29. Western Mines Ltd.
30. Cominco Ltd. (Coast Copper)
31. Falconbridge Nickel Mines, Ltd. (Wesfrob)

PROSPECTIVE PRODUCERS

32. Madeleine Mines Ltd.
33. D'Estrie Mining Company Ltd.
34. Jameland Mines Ltd.
35. Falconbridge Nickel Mines Ltd. (2 mines)
    The International Nickel Company of Canada Ltd. (5 mines)
36. Big Nama Creek Mines Ltd.
37. The International Nickel Company of Canada, Ltd. (1 mine)
38. Maskwa Nickel Chrome Mines Ltd.
39. Hudson Bay Mining and Smelting Co., Ltd. (2 mines)
40. Hudson Bay Mining and Smelting Co., Ltd. (1 mine)
41. Sherritt Gordon Mines, Ltd. (Fox mine)
42. Brenda Mines Ltd.
43. Granduc Mines, Ltd.

REFINERIES

14. The International Nickel Company of Canada, Ltd.
44. Canadian Copper Refiners Ltd.

TABLE 4

Prospective Producing Companies* 1968

Company and Location	Type of Ore	Mill or Mine Capacity (tons ore/day)	Production to Start	Destination of Concentrates
Quebec				
D'Estrie Mining Company Ltd., Stratford Centre	Cu, Zn	. . (will be milled at Cupra)	1970	Export market
Madeleine Mines Ltd., Gaspe Provincial Park	Cu	2,500	1969	Murdochville
Ontario				
Big Nama Creek Mines Limited, Manitouwadge	Zn, Cu	. . (will be milled at Willroy)	1969	Noranda
The International Nickel Company of Canada, Limited, Copper Cliff				
Kirkwood mine	Ni, Cu	. .	1969	Own smelter
Little Stobie	Ni, Cu	6,000 (will be milled at Frood-Stobie)	1969	Own smelter
Coleman mine	Ni, Cu	. .	1970	Own smelter
Copper Cliff South mine	Ni, Cu	. .	1971	Own smelter
The International Nickel Company of Canada, Limited, Shebandowan mine, Shebandowan	Ni, Cu	2,900	1972	Copper Cliff
Jameland Mines Limited, Timmins	Zn, Cu	–		20,000 tons of ore a month trucked to Kam-Kotia mill
Manitoba-Saskatchewan				
Hudson Bay Mining and Smelting Co., Limited				
Flexar mine, Sask.	Zn, Cu	. .	1969	Ore will be trucked to Flin Flon
Anderson Lake mine, Snow Lake, Manitoba	Cu, Zn	. .	1969	Ore will be shipped to Flin Flon
Dickstone mine, Snow Lake, Manitoba	Cu	. .	1970	Ore will be shipped to Flin Flon
Maskwa Nickel Chrome Mines Limited, Bird River, Manitoba	Ni, Cu	. .	1969	Ore will be trucked to Consolidated Canadian Faraday
Sherritt Gordon Mines, Limited. Fox Lake mine, Manitoba	Cu, Zn	3,000	1970	Japan
British Columbia				
Brenda Mines Ltd., Peachland	Cu, Mo	24,000	1969	Japan
Granduc Mines, Limited, Unuk River	Cu	7,000	1969	U.S.A.

Source: Company reports.
*Includes only companies with announced production plans.
. .Not available.

TABLE 5

Canadian Copper and Copper-Nickel Smelters

Operator and Location	Product	Rated Annual Capacity (short tons)	Remarks	Ore and Concentrate Treated, 1968 (short tons)	Blister or Anode Copper Produced, 1968 (short tons)
Falconbridge Nickel Mines, Limited, Falconbridge, Ont.	Copper-nickel matte	650,000 (ores and concentrates)	Copper-nickel ore and prepared 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	300,000 (ores and concentrates)	One reverberatory furnace for green or wet-charge concentrates, 2 Pierce-Smith converters, 1 anode furnace, 1 Walker casting wheel. Also smelts custom concentrates.	335,600 (of which 107,000 were custom concentrates)	61,100
Hudson Bay Mining and Smelting Co., Limited, Flin Flon, Man.	Blister-copper cakes	575,000 (ores and concentrates)	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.	400,500 (of which 32,100 were custom concentrates)	42,302
The International Nickel Company of Canada, Limited					
Coniston, Ont.	Copper-nickel Bessemer matte	800,000 (ores and concentrates)	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 (ores and concentrates)	Oxygen flash-smelting of copper sulphide concentrates; 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.	. .	. .

TABLE 5 (Cont'd)

Operator and Location	Product	Rated Annual Capacity (short tons)	Remarks	Ore and Concentrate Treated, 1968 (short tons)	Blister or Anode Copper Produced, 1968 (short tons)
			then by sintering to make sintered-nickel products for refining and marketing. Electric-furnace melting of copper sulphide and conversion to blister copper.		
Noranda Mines Limited, Noranda, Que.	Copper anodes	1,700,000 (ores and concentrates and scrap)	Roasting furnaces, 2 hot-charge reverberatory furnaces, 1 green-charge reverberatory furnace, 5 converters. Also smelts custom material.	1,613,800 (of which 790,900 were custom material)	221,500

Source: Company reports.
. .Not available.

TABLE 6

Copper Refineries in Canada, 1968

Refinery	Products
Canadian Copper Refiners Limited, Montreal East, Quebec. (subsidiary of Noranda Mines Limited)	Rated annual capacity: 342,000 tons. Refines anode copper from Noranda and Gaspe 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: 168,000 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.

WORLD MINE PRODUCTION

The accompanying graph on copper production and consumption illustrates much about the world structure of the copper industry. The communist bloc countries have a virtual balance in supply and consumption. The excess refined output can probably be explained by reprocessed scrap.

In the non-communist world, mine production is concentrated in Africa, United States, South America and Canada. United States, Japan and Europe have excess refinery capacity indicating that, in addition to scrap, these areas must import ores, concentrates and blister copper to maintain full production.

Ninety per cent of the copper consumed in the non-communist world is used in United States, Europe, Japan and Canada. These areas produce 74 per cent of the refined copper and only 45 per cent of mine output, outside of the centrally planned countries. From this it can be seen that about 52 per cent of the non-communist world's copper is produced from the mines in lesser developed areas that consume about 8 per cent of the total output. Most of the lesser developed producing countries derive a major portion of their national revenue from the copper mining industry and these countries are moving rapidly to increase production and to increase the national participation in the mining industry. This increased participation has taken the form of government financial participation in the mining-refining complexes, i.e., Chile and Congo (Kinshasa) or of increased taxation and/or retention of part or all of the profits within the country for reinvestment, i.e., Zambia and Peru.

The major African and South American producing countries have formed an association to study the interrelationship of markets, supply and prices. It is expected that this organization will make recommendations to their respective government organizations on actions that might be taken to ensure a stable and reasonably profitable price level.

New copper production is scheduled in many countries including Canada, United States, Chile, Peru, Philippines, Yugoslavia, Australia, and Bougainville. World estimates of production expansions in non-communist areas vary, but a check of published information indicates the following increases in mine production by 1973: Canada, 256,000 tons; United States, 249,000 tons; Chile, 359,000 tons; Peru, 156,000 tons; Zambia, 9,100 tons; other 205,000 tons; a total of 1,316,000 tons. This total is probably conservative since it includes only the announced plans and does not take into account the possibility of production from large deposits presently under investigation.

TABLE 7

Canada, Consumption of Primary Copper in Manufacture of Semi-fabricated Products, 1966-67
(short tons)

	1966	1967
Copper mill products, sheet, strip, bars, rolls, pipe, tube, etc.	73,343	50,338
Brass mill products–plate, sheet, strip, rods, bars, rolls, pipe, tubes, etc.	21,446	12,942
Wire and rod mill products	122,098	83,908
Miscellaneous	1,119	1,534
Total	218,006	148,722

Non-communist world production of refined copper by 1973 should approximate 7,200,000 tons, allowing for 19 per cent of supply from scrap. If consumption to 1973 rises at an average 4.5 per cent a year there will be an indicated minimum oversupply of 200,000 tons of copper a year by 1973. This would probably have little or no effect on 1973 prices since an estimated 3 per cent of the industry is idle at any one time because of labour or political disturbances.

USES

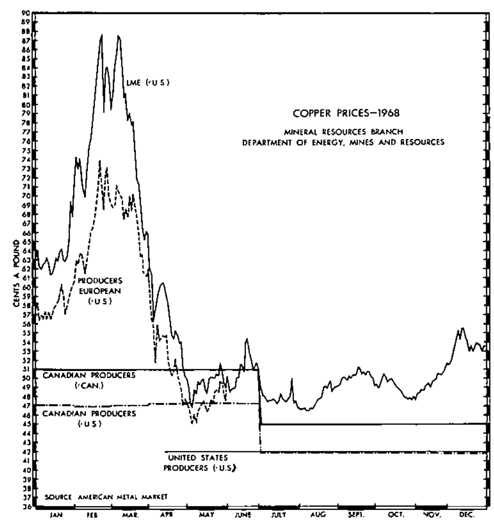
Copper's properties of malleability, ductility, conductivity, corrosion resistance, alloying qualities and pleasing appearance make its use universal in the electrical, construction, plumbing and automotive industries. Approximately half of all copper consumed is for electrical applications, including 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 non-corrosive 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 fittings for marine hardware. In the automotive industry copper is used for radiators, wires, bearings, bushings, switches and oil lines.

The principal copper and brass fabricators in Canada are: in British Columbia – Noranda Copper Mills Ltd., Western Division, Vancouver; in Ontario – Anaconda American Brass Limited, Toronto, Phillips Cables Limited, Brockville, Ratcliffs (Canada) Limited, Richmond Hill, Wolverine Tube Division of Calumet & Hecla (Canadian) Limited, London; in Quebec – Noranda Copper Mills Ltd., Eastern Division, Montreal East, Pirelli Canada Ltd. (Pirelli Cables Limited), St. John's and Northern Electric Company, Limited, Montreal.

PRICES

Copper pricing varies with the area in which the metal is produced and sold. In 1968 there were three basic prices for copper mined, processed and sold by the producers. In North America there was the United States producer's price and the Canadian producer's price. Copper sold in the United States and Europe by foreign producers was priced on the basis of the London Metal Exchange (LME) price.



The accompanying graph indicates the fluctuations in these three prices in 1968. The industry-wide strike at the mines and plants in the United States lasted until April. Up to the time at which the United States producers had domestic copper to sell, there was no United States producer quote. After production was resumed the price settled at 42 cents (U.S.) a pound, 4 cents higher than in the latter part of 1967. This price held for the remainder of the year. In Canada, the producer price was 51 cents (Can.) a pound until the end of June at which time it was reduced to 45 cents for the remainder of the year. The producers price in Europe was based on the LME forward price (the price for copper to be delivered in three months) until June at which time the producers switched their pricing base to the LME spot price. The strike in the United States caused an estimated loss in production of 800,000 tons of copper and prices on the LME reacted to this loss, rising to a high of 87.64 cents (U.S.) a pound in February. News of the strike settlement and the resumption of producer price quotes in the United States caused a rapid decline in the LME spot price to 46.71 cents in May. The spot price quotation fluctuated between 46 and 54 cents a pound for the remainder of the year.

TARIFFS

Copper entering Canada in ores and concentrates is not subject to tariff. Various tariff rates are in effect for the copper content in bars, rod, wire, semi-fabricated forms and fully processed products entering the country.

TABLE 8

World Copper Mine Production, 1967-68
(short tons)

	1967	1968p
United States	954,064	1,199,000
Communist countries	1,105,950	1,100,000
Chile	731,789	730,000
Zambia	729,995	750,000
Canada	613,313	620,071
Congo (Kinshasa)	353,314	350,000
Peru	199,668	250,000
Republic of South Africa	140,583	. .
Japan	129,692	. .
Australia	98,188	. .
Other countries	389,899	850,000
Total	5,446,455	5,849,071

Source: For 1967, U.S. Bureau of Mines, Minerals Yearbook 1967; for 1968, U.S. Bureau of Mines, Commodity Data Summaries, January 1969.

pPreliminary; . .Not available.

The United States tariff on copper entering the country in ores, concentrates and primary shapes remains suspended. The duty prior to January 1, 1968 was 1.7 cents a pound of contained copper. This has subsequently reduced under GATT provisions to 1.3 cents a pound effective January 1, 1969. On fabricated products an ad valorem duty that varies with the type of product is added to the basic tariff on copper content.

TABLE 9

Canadian Tariffs*

	Most Favoured Nation
Ores, concentrates, pigs, blocks and ingots and anodes	free
Oxides	15%
Bars and rods for manufacture of wire and cable	8%
Bars or rods, tubing not less than 6 feet long, unmanufactured; copper in sheets, strips or plates not polished planished or coated	8%
Tubing not more than ½ in. in dia. and not less than 6 feet long	8%

*Effective January 1, 1969.

Sources: The Custom Tariff and Amendments Department of National Revenue, Customs and Excise Division, Ottawa.

Tariff Schedules of the United States Annotated (1969) TC Publication 272.

Fluorspar

P.R. COTE*

Fluorite, CaF_2 also commonly referred to as fluorspar, is a naturally occurring mineral and is the principal source of the element fluorine. Fluorite occurs in a great range of geological environments from low-temperature fracture fillings to high-temperature emplacements. Because of this, fluorite is not restricted to any particular geological province in Canada and is known to occur in all physiographic regions with the exception of the Great Plains.

Growth in world fluorspar consumption has been rapid in the past decade reflecting increasing demands from the aluminum, steel and chemical industries. In order to supply these rapidly expanding markets, many new mines throughout the world came into production and many existing mines increased capacity during 1968. The growing use of the basic oxygen process in steelmaking which requires three to five times more fluorspar, as a slag thinner, than the open-hearth process will add to fluorspar demands in the immediate future. In addition, increasing markets for aluminum and fluorocarbon compounds will further stimulate demand. Larger demand and higher prices for all grades of fluorspar may provide, in the near future, sufficient impetus for additional fluorspar mines in Canada.

PRODUCTION AND DEVELOPMENTS IN CANADA

Virtually all fluorspar produced in Canada is mined from the Burin Peninsula area in Newfoundland. Very minor tonnages are recovered from the silica operations of Pacific Silica Limited near Oliver, British Columbia. Value of production increased from $2,099,855 in 1967 to $2,474,362 in 1968. For the second year in a row, Canada became a net importer of fluorspar.

Newfoundland Fluorspar Limited, a wholly owned subsidiary of the Aluminum Company of Canada, Limited (Alcan) 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 approximately 26 years. In August 1968, the Tarefare was brought into production and is scheduled to produce some 25,000 tons a year of fluorspar concentrate, all of which will be shipped, together with production from the Director mine, to Alcan's aluminum smelter at Arvida. The concentrate is upgraded and then converted to artificial cryolite which is an essential requirement for the reduction of alumina to aluminum. A third mine in the same area may be developed by the mid-1970's. The deposits on the Burin Peninsula constitute a major reserve and have a life expectancy of some 25 years at present production rates.

Allied Chemical Canada, Ltd. imports acid-grade fluorspar for the production of hydrofluoric acid at the company's plant located at Valleyfield, Quebec. A portion 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.

Huntingdon Fluorspar Mines Limited with a plant at North Brook, Ontario, imports metallurgical-grade fluorspar to make 5-pound briquettes for foundry use.

Some fluorine is being recovered as fluosilicic acid, from the processing of phosphate rock by

*Mineral Resources Branch.

TABLE 1

Canada, Fluorspar, Production, Trade and Consumption

	1967		1968p	
	Short Tons	$	Short Tons	$
Production (shipments)				
Newfoundland	..	2,097,391	..	2,473,500
British Columbia	..	2,464	..	862
Total		2,099,855		2,474,362
Imports				
Mexico	79,027	2,016,000	97,619	2,556,000
United States	10,606	400,000	9,938	405,000
Britain	4,611	193,000	7,908	316,000
Total	94,244	2,609,000	115,465	3,277,000
	1966		1967	
Consumption (available data)				
Metallurgical flux[1]	42,555		32,854	
Glass	2,761		1,120	
Enamels	290		260	
Other[2]	120,669		121,115	
Total	166,275		155,349	

Source: Dominion Bureau of Statistics.
[1]Consumption as flux in the production of steel, magnesium and use in foundries.
[2]Includes consumption in the production of aluminum and chemicals and other miscellaneous uses.
[p]Preliminary; . .Not available.

TABLE 2

Canada, Fluorspar, Production, Trade and Consumption, 1959-68
(short tons)

	Production	Exports	Imports	Consumption
1959	74,000[1]	3,774	26,588	96,016
1960	77,000[1]	10,312	59,690	111,835
1961	78,600[2]	2,048	32,769	111,542
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	112,000[2]	..	69,848	167,537
1966	84,000[e]	12	75,324	166,275
1967	73,000[e]	..	94,244	155,349
1968	100,000[e]	..	115,465	..

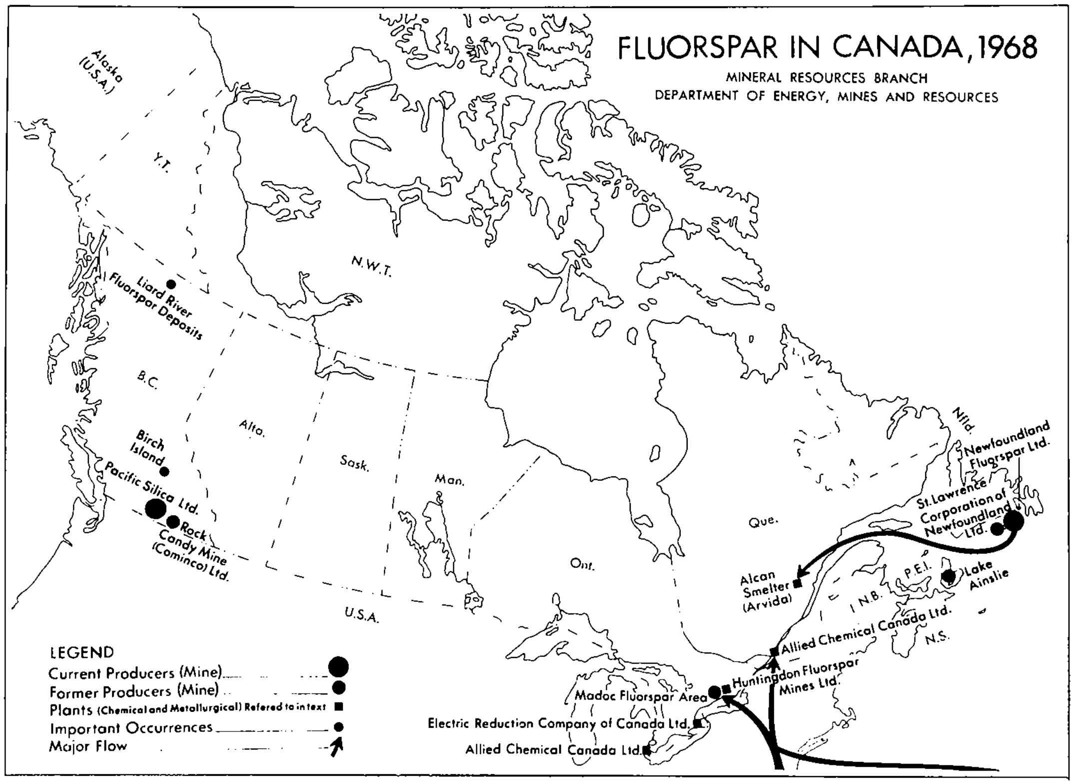
Source: Dominion Bureau of Statistics, except where otherwise indicated.
[1]Estimates reported by U.S. Bureau of Mines.
[2]Shipments reported in annual reports of Aluminum Limited.
. . Not available; [e]Estimated.

Electric Reduction Company of Canada, Ltd., at Port Maitland, Ontario and by Cominco Ltd., at Trail, British Columbia.

International Mogul Mines Limited, continued assessing barite – fluorite deposits east of Lake Ainslie on Cape Breton Island, Nova Scotia. Tests have been made to determine if acceptable fluorite and barite concentrates can be produced. Recent drilling has indicated at least 2.5 million tons grading 46 per cent barite and 14 per cent fluorite. From 1940 to 1949, approximately 1,400 tons of fluorspar was obtained, with some barite, from this deposit.

OTHER DOMESTIC SOURCES

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 to the aluminum and iron industry, showed a marked increase in production during the war years. After World War I production decreased substantially but was stimulated once again during the second World War by government assistance by way of exploratory drilling programs and 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 problems, 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. The majority of significant producing properties were along a prominent linear vein structure the southern extension of which could still contain economically attractive reserves.

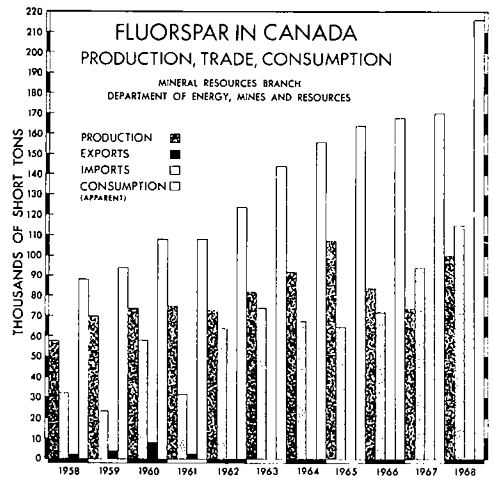
Fluorite occurs in several areas in British Columbia. The Rock Candy mine, near Grand Forks, was mined intermittently from 1918 to 1942 and is still controlled by Cominco Ltd. Substantial reserves probably remain but Cominco recovers all the fluorine it requires from the processing of phosphate rock for fertilizer manufacture. Consolidated Rexspar Minerals & Chemicals Limited has a large medium-grade fluorite deposit adjacent to the rail line at Birch Island, about 60 miles north of Kamloops. The fluorite is fine-grained and difficult to concentrate, but higher prices and the greater use of pelletized metallurgical-grade fluorspar may result in production at some future time. Shallow flat-lying deposits along the Liard River in northern British Columbia apparently contain large quantities of fluorite, barite and witherite, but without higher prices and a much improved means of transportation the deposits are uneconomic.

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, these are: acid grade containing a minimum of 97 per cent CaF_2 and a maximum of 1 per cent SiO_2; metallurgical grade containing 75 to 80 per cent CaF_2 with a maximum of 5 per cent SiO_2; ceramic grade containing 93 to 95 per cent CaF_2, and not more than 3 per cent SiO_2, 1 to 3 per cent $CaCO_3$ and less than 0.1 per cent Fe_2O_3.

Currently, slightly less than one half of all fluorspar consumed in Canada, and almost all domestic production, is used in the manufacture of artificial cryolite (Na_3AlF_6). Acid-grade fluorspar is first converted to hydrofluoric acid prior to the manufacture of cryolite which along with aluminum fluoride (AlF_3) forms the electrolyte flux in the Hall process for converting alumina to aluminum. A small amount of fluorspar is added to the electrolyte for make-up purposes.



Hydrofluoric acid used in the chemical industry is manufactured by reacting sulphuric acid with acid-grade fluorspar according to the reaction: $H_2SO_4 + CaF_2 \rightarrow CaSO_4 + 2HF$. Much of the acid produced from imported fluorspar is utilized in the manufacture of aerosol propellants, refrigerants, plastics and various solvents. Slightly over one quarter of fluorspar consumed in Canada is used in the chemical industry.

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. Approximately 17 per cent of fluorspar consumed in Canada is utilized in the manufacture of steel which requires 3 to 7 lb of fluorite per ton of steel produced by open hearth furnaces, 12 to 16 lb by the basic oxygen process and 8 to 10 lb by electric furnaces. For fluxing purposes, fluorspar is purchased in lump or gravel form and should contain a minimum of 60 per cent CaF_2. Silica is an objectionable impurity as well as barite both of which decrease the fluidity of the melt. The use of pelletized flotation concentrates is now receiving attention in the United States and this may become the preferred form for adding fluorspar to oxygen steel furnaces. Metallurgical-grade fluorspar is also used as a flux in foundries and in the reduction of dolomite to magnesium.

Ceramic-grade fluorspar currently accounts for some 3 per cent of consumption in Canada and 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.

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.

For the second consecutive year, Canada imported more fluorspar than it produced. Imports increased 22.5 per cent over 1967 and now account for 56 per cent of apparent domestic consumption. In fact, virtually all fluorspar consumed outside of the aluminum industry is imported. Shipments from Mexico, where major Canadian consumers of fluorspar operate mines, accounted for 85 per cent of imports while the United States accounted for 9 per cent and Britain 6 per cent.

Prior to 1957 Canada exported a large portion of production to the United States and Europe. However, in 1958 exports declined abruptly due to the development of alternative low-cost deposits in Mexico by large consumers in the United States. Competition from these deposits in Mexico forced the closure of a number of producers in Canada who had formerly relied upon exports to the United States.

WORLD REVIEW

The increased demand for fluorspar due to growing consumption in the aluminum, steel and chemicals industries is world-wide and has led to many new and enlarged operations.

Mexico continued as the world's largest supplier with a production of about 850,000 tons in 1968. There are in operation at the present time; nine flotation plants, and three dressing plants served by some thirty producing mines. Mining and chemical companies operating in Canada that have deposits in Mexico include: Noranda Mines Limited, Allied Chemical Corporation, and Alcan. The rapid growth of Mexican fluorspar production has paralleled consumption increases in the United States. Over 90 per cent of Mexican exports are to the United States with most of the remainder going to Canada. Current capacity in Mexico is in the order of 1 million tons a year. In the United States, mining activity increased markedly in 1968 as a result of a much stronger demand for acid-grade fluorspar by the chemical industry plus a growing demand for fluorspar pellets for use in basic oxygen steelmaking plants. In France, there has been a great increase in fluorspar mining

TABLE 3

World Production of Fluorspar
(short tons)

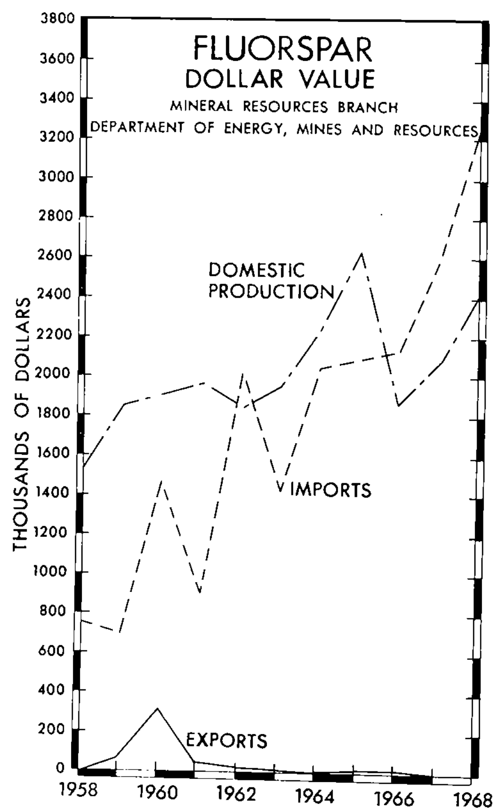
	1966	1967	1968[e]
Mexico	799,602	785,114	850,000
USSR	385,000	420,000	. .
United States	253,000	295,000	330,000
China, mainland	280,000	280,000	. .
Spain	230,315	267,509	. .
France	237,476	243,000	300,000
Britain	138,891	. .	220,000
Italy	215,193	224,000	230,000
Thailand	52,941	146,775	210,000
Republic of South Africa	90,266	108,000	120,000
Other countries	446,521	380,447	1,240,000
Total	3,129,205	3,150,488	3,500,000

Source: For 1966 and 1967 U.S. Bureau of Mines, Minerals Yearbook, 1967; for 1968 various sources including U.S. Bureau of Mines Commodity Data Summaries, January 1969.
[e]Estimated; . . Not available.

owing to the discovery of new deposits in the middle of France, the Massif Central and in the Alpine region. The fastest developing new source of fluorspar in the world is Thailand where production has risen from 3,400 tons in 1960 to an estimated 211,000 tons in 1968. Other major increases in producing capacity took place in India, Korea, Tunisia, South Africa, Spain and Britain. Total world production in 1968 is estimated at 3.5 million tons.

OUTLOOK

World steel production is expanding rapidly as is the aluminum industry. Even greater growth rates are forecast for some sectors of the chemical industry. There is no satisfactory substitute for fluorspar either as a metallurgical flux or in the manufacture of hydrofluoric acid, an essential raw material used in the aluminum industry and by the chemical industry for the manufacture of fluorocarbons for aerosols, plastics and refrigerants. By 1975, world requirements for fluorspar could easily exceed 5 million tons requiring the mining of some 15 million tons of ore a year. Known world reserves have been estimated at 150 million tons equivalent to some ten years supply at projected consumption in the mid 1970's. Increased demands have resulted in a marked increase in exploration and mine development. In spite of this, proven reserves must be considered limited and further activity in developing new fluorspar reserves will take place.



PRICES

United States fluorspar prices quoted in the *Engineering and Mining Journal* of December 1968 were as follows:

per short ton, f.o.b. mill, Illinois and Kentucky, CaF_2 content, bulk

Metallurgical	
72½%	\$41.50 – \$42.50
70%	41.50
60%	38.50
Pellets	
70%, effective	\$46.50
Acid, dry basis, 97%	
Carloads	54.00
Less than carloads	55.00
Bags, extra	4.00
Pellets, 90% effective	52.00
Wet filter cake, 8–10% moisture, sold dry content – subtract approx.	2.50
Ceramic, calcite and silica variable, Fe_2O_3, max. 0.14%	
88–90%	47.50
93–94%	50.50
95–96%	51.50
97%	53.50
in 10 lb paper bags, extra	4.00
European	
c.i.f. U.S. ports, duty paid, per short ton	
Acid, wet filter cake, 8–10% moisture, sold dry content	\$44.50 – 47.00
Mexican	
Metallurgical, 72½%	
f.o.b. per short ton Border, all rail, duty paid	33.00 – 34.00
Brownsville, barge, duty paid	35.00 – 36.50
Tampico, vessel, cargo lots	27.00 – 27.50
Acid, 97% + Eagle Pass, bulk	40.00 – 41.00

TARIFFS

Item No.		Most Favoured Nation Before Jan. 1 1968	On and After Jan. 1 1968	On and After Jan. 1 1969
	CANADA			
29600–1	Fluorspar	free	free	free
	Source: The Custom Tariff and Amendments, March 1969.			
	UNITED STATES			
522.21	Fluorspar, containing over 97% calcium fluoride	\$2.10/lt	\$2.10/lt	\$2.10/lt
522.24	Fluorspar, containing not over 97% calcium fluoride	\$8.40/lt	\$8.40/lt	\$8.40/lt

Source: Tariff Schedules of the United States Annotated, 1969.

Gold

J.J. HOGAN*

Gold production in Canada in 1968 declined for the eighth successive year. Production in 1968 is estimated at 2,748,333 troy ounces valued at $103,639,636 based on the average mint price for the year. In comparison with the 1967 production of 2,986,268 ounces valued at $112,731,618 the 1968 production is down about 8 per cent. The decline is expected to continue in 1969. The highest production since World War II was achieved in 1960 when 4,628,911 ounces valued at $157,151,527 were produced.

The 1968 decrease in production is mainly attributable to the closure of auriferous-quartz or lode gold mines. In 1968 lode gold mines produced 2,207,533 ounces compared with 2,426,137 ounces in 1967. Five lode gold mines closed in 1968 and one mine came into production. Ontario continued as the leading producing province in 1968 producing 49.5 per cent of the total. Quebec was in second place with 28.1 per cent. The Northwest Territories produced 12.6 per cent and British Columbia 4.6 per cent.

World production in 1967 was estimated at 44.9 million troy ounces by the U.S. Bureau of Mines. In 1966 world production was 46.6 million ounces. About 68 per cent of the 1967 total or 30.53 million ounces was produced by the Republic of South Africa. The USSR produced an estimated 5.70 million ounces in 1967.

Canada has long been one of the world's leading producers of gold. Since production was first officially recorded in 1858, Canada has produced over 186.5 million ounces worth about $6,055 million to the end of 1968. Although most provinces have been contributors to the total, Ontario, Quebec, British Columbia, Yukon Territory and the Northwest Territories, in that order, are the leaders.

Since 1948, production by the gold mining industry has received financial assistance from the Government of Canada under provisions of the Emergency Gold Mining Assistance Act. In December 1967, the act was extended for three years to the end of 1970. In 1968 there were 35 lode gold mine operators eligible for assistance. Four lode gold mines do not receive assistance payments.

The closure of five gold mines in 1968 was due to the exhaustion of economic ore. Two mines will probably suspend operations in 1969. Many of the mines are experiencing difficulty in maintaining operations due to rising costs.

Gold recovered from placer mines is now of minor importance.

*Mineral Resources Branch.

TABLE 1

Production of Gold, 1967-68
(troy ounces)

	1967	1968p
NEWFOUNDLAND		
Base-metal mines	27,258	22,757
NOVA SCOTIA		
Auriferous quartz	1	–
NEW BRUNSWICK		
Base-metal mines	1,421	1,859
QUEBEC		
Auriferous quartz mines		
Bourlamaque-Louvicourt	248,168	207,283
Malartic	235,215	225,075
Chibougamau	27,730	22,934
Noranda	50,347	62,192
Total	561,460	517,484
Base-metal mines	273,730	255,369
Total Quebec	835,190	772,853
ONTARIO		
Auriferous quartz mines		
Kirkland Lake	124,885	111,019
Larder Lake	200,835	179,155
Porcupine	637,506	563,179
Red Lake and Patricia	363,121	335,268
Sudbury	33,266	38,500
Thunder Bay	57,174	54,173
Total	1,416,787	1,281,294
Base-metal mines	78,598	80,175
Total Ontario	1,495,385	1,361,469
MANITOBA-SASKATCHEWAN		
Auriferous quartz mines	13,393	7,943
Base-metal mines	88,447	81,757
Total Manitoba and Saskatchewan	101,840	89,700
ALBERTA		
Placer operations	146	100
BRITISH COLUMBIA		
Auriferous quartz mines	54,192	53,800
Base-metal mines	71,952	73,326
Placer operations	679	500
Total British Columbia	126,823	127,626
YUKON		
Base-metal mines	9,314	17,100
Placer operations	8,586	7,857
Total Yukon	17,900	24,957

TABLE 1 (Cont'd)

	1967	1968P
NORTHWEST TERRITORIES		
Auriferous quartz mines	380,304	347,012
CANADA		
Auriferous quartz mines	2,426,137	2,207,533
Base-metal mines	550,720	532,343
Placer operations	9,411	8,457
Total	2,986,268	2,748,333
Total value	$112,731,618	$103,639,636
Average value per oz	37.75	37.71

Source: Dominion Bureau of Statistics.
PPreliminary; – Nil.

OPERATIONS AT PRODUCING MINES

ATLANTIC PROVINCES

Gold production in Newfoundland, Nova Scotia and New Brunswick amounted to 24,616 troy ounces in 1968 compared with 28,680 ounces in 1967. Production is derived mainly from base-metal mining in Newfoundland. Consolidated Rambler Mines Limited, a Newfoundland copper-zinc producer, is the largest producer of byproduct gold. Some gold is recovered from base-metal ores in New Brunswick while Nova Scotia intermittently produces small amounts of gold from auriferous quartz deposits.

QUEBEC

Gold production in Quebec amounted to 772,853 fine ounces, a decrease of 7.5 per cent over the previous year. Ten lode gold mines operated in 1968.

One of the ten producing gold mines came into production during the year. Production in 1968 decreased both from lode gold mines and from byproduct base-metal mines. The base-metal mines accounted for about 33 per cent of the provincial gold total as against 32.8 per cent in 1967. The principal producers of byproduct gold are the base-metal mines of the Chibougamau and Noranda districts.

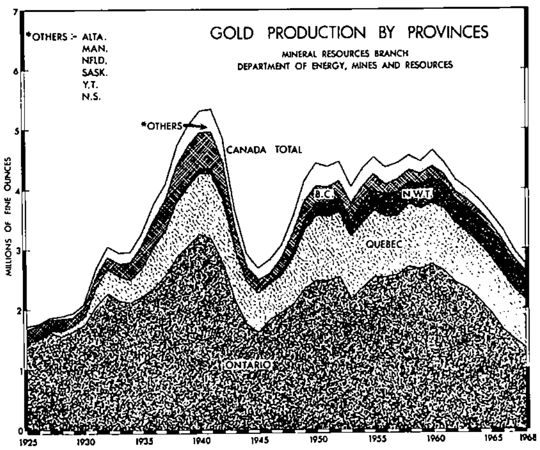
Auriferous Quartz Mines

Bourlamaque-Louvicourt District. Two lode gold mines operated in the district in 1968 compared with four in 1967, resulting in a substantial decline in production. Production at Lamaque Mining Company Limited (Lamaque Division) decreased slightly in 1968 and at Sigma Mines (Quebec) Limited increased by a small margin.

Malartic District. Five lode gold mines operated in the area in 1968, the same number as in 1967. Production for the district decreased by 4.3 per cent as compared to 1967. Barnat Mines Ltd. closed its mill early in 1968 but continued to ship ore to the custom mill of Malartic Gold Fields (Quebec) Limited. Production at Barnat decreased substantially during the year mainly because of a 48 per cent decline in tonnage of ore treated. Camflo Mines Limited had a small decline in production. Camflo's ore is treated at the custom mill of Malartic Gold Fields. The agreement between the two companies for the treatment of the ore expires the end of June, 1969. Camflo is constructing a 1,000 ton a day cyanide plant which is scheduled to be in operation by July 1, 1969. A shaft deepening program was carried out in 1968. East Malartic Mines, Limited installed extra mill equipment in 1968, increasing the rated mill capacity from about 1,500 tons to 1,800 tons a day. Production increased substantially on account of an increase in tonnage and grade of ore treated. The Little Long Lac Gold Mines Limited produced a small amount of gold from its property adjoining Marban Gold Mines Limited. Marban increased production in 1968 as compared with 1967. Marban and Little Long Lac ores are treated at the custom mill of Malartic Gold Fields.

Chibougamau District. Production from Norbeau Mines (Quebec) Limited, the only lode gold producer in the area declined in 1968. Ore reserves are near depletion and the mine is expected to suspend operations in 1969.

Noranda District. Production at Wasamac Mines Limited (No. 1 Mine) decreased by a small margin. The No. 2 Mine of Wasamac began shipping to the mill at Wasamac No. 1 Mine in May 1968. Ore is trucked about five miles.



ONTARIO

Twenty lode gold mines operated in the province in 1968, compared with twenty-one in 1967. Three lode mines suspended operations in 1968, one of these being Hollinger Mines Limited. Surluga Gold Mines Limited, near Wawa, produced a small amount of gold in 1968. Gold produced from the lode gold mines of Ontario declined by about 9.6 per cent in 1968 compared with 1967.

Auriferous Quartz Mines

Kirkland Lake District. Three lode gold mines operated in this district in 1968. Macassa Gold Mines Limited increased production by approximately 9.6 per cent. Lamaque Mining Company Limited (Teck-Hughes Mining Division) extracted all ore and suspended operations in February. The mine began producing in 1917. Production at Upper Canada Mines, Limited was about the same as in 1967.

Larder Lake District. Production at Kerr Addison Mines Limited declined in 1968. In April 1968, Kerr Addison purchased all assets, by the allotment and issue of treasury shares, of Quemont Mining Corporation, Limited and Normetal Mining Corporation, Limited.

Porcupine District. Production at Aunor Gold Mines Limited and at Pamour Porcupine Mines, Limited increased in 1968. To combat increasing costs Pamour successfully introduced a rubber tired load-haul-dump unit underground. Dome Mines Limited and the Ross Mine of Hollinger at Holtyre increased production by a small margin. Hallnor Mines, Limited maintained production at the 1967 level. Hollinger Mines Limited suspended mining operations at its gold producing property in the Timmins area in May. The mine began production in 1910 and has produced more gold than any other mine in Canada. Production at McIntyre Porcupine Mines Limited declined slightly. McIntyre maintained tonnage of ore treated at the 1967 level. Preston Mines Limited, after twenty-nine years of production, closed its lode gold mine in June.

Sudbury Mining Division. Production at Renabie Mines Limited, near Missinabie declined in 1968 as compared to 1967.

Thunder Bay Mining Division. MacLeod Mosher Gold Mines Limited, situated near Geraldton, is the only operating lode gold mine in the area. Production was up slightly in 1968.

Red Lake and Patricia Mining Division. Six lode gold mines operated in the district in 1968, the same number as in 1967. Production declined by about 7.7 per cent compared with 1967. Wilmar Mines Limited recorded its first full year of production. Annco Mines Limited and Cochenour Willians Gold Mines, Limited suffered sharp declines in production. Production decreased at both Dickenson Mines Limited and Madsen Red Lake Gold Mines Limited. Campbell Red Lake Mines Limited increased production in 1968 by about 5.6 per cent compared with 1967 and was the largest producing lode gold mine in Canada in 1968.

Base-Metal Mines

Byproduct gold was recovered from the copper-nickel ores of the Sudbury area and the zinc-copper mines at Manitouwadge. McIntyre Porcupine Mines and Upper Beaver Mines Limited near Kirkland Lake produce appreciable amounts of gold from copper-gold ores.

PRAIRIE PROVINCES

San Antonio Gold Mines Limited, at Bissett, Manitoba, the only producing lode gold mine in the Prairie Provinces, suspended mining operations in June. A fire destroyed the surface hoisting facilities about the middle of June and shortly thereafter, the company was placed in receivership.

Hudson Bay Mining and Smelting Co., Limited recovered byproduct gold from its base-metal operations in the Flin Flon and Snow Lake areas. Anglo-Rouyn Mines Limited, near Lac La Ronge in Saskatchewan, increased its production of byproduct gold. The International Nickel Company of Canada, Limited produced some byproduct gold from the nickel-copper ores in the Thompson Lake area in Manitoba.

A small amount of gold is recovered by gravel-washing operations on the North Saskatchewan River near Edmonton, Alberta.

BRITISH COLUMBIA

Bralorne Pioneer Mines Limited is the only remaining operating lode gold mine in the province. Produc-

TABLE 2

World Gold Production, 1966-67
(troy ounces)

	1966	1967
NORTH AMERICA		
Canada	3,319,474	2,986,268
United States	1,803,420	1,584,187
Nicaragua	199,108	177,702
Mexico	213,609	181,491
Other countries	9,915	6,424
Total	5,545,526	4,936,072
SOUTH AMERICA		
Colombia	280,823	258,186
Brazil	167,955	172,000
Peru	94,978	95,559
Bolivia	86,982	55,069
Chile	74,513	55,964
Other countries	36,687	25,796
Total	741,938	662,574
EUROPE		
USSR	5,370,000	5,700,000
Sweden	115,000[e]	. .
Yugoslavia	84,942	86,000
Other countries	95,926	48,500
Total	5,665,868	5,834,500
ASIA		
Philippines	454,546	500,417
Japan	256,395	252,769
Korea	220,765	223,337
India	120,244	97,256
Other countries	115,697	94,176
Total	1,166,647	1,167,955
AFRICA		
Republic of South Africa	30,879,700	30,532,880
Ghana	684,395	762,609
Southern Rhodesia	550,000	. .
Congo (Kinshasa)	158,632	153,520
Other countries	155,156	87,191
Total	32,427,883	31,536,200
OCEANIA		
Australia	914,732	627,171
Fiji	112,567	111,108
New Guinea	28,068	27,628
Other countries	9,003	43
Total	1,064,370	765,950
WORLD TOTAL	46,612,232	44,903,251

Source: Minerals Year Book, United States Bureau of Mines and for Canada, Dominion Bureau of Statistics.

[e]Estimated; . . Not available.

tion in 1968 increased. A small amount of placer gold is recovered, chiefly in the Cariboo district.

Byproduct gold recovered from base-metal mines increased by a small amount in 1968 compared with 1967. The Phoenix Copper Division of The Granby Mining Company Limited, Granisle Copper Limited, and Coast Copper Company, Limited were the three largest contributors. The recovery of gold from the iron-copper ore of Wesfrob Mines Limited which is located on Queen Charlotte Islands and controlled by Falconbridge Nickel Mines, Limited increased appreciably in 1968.

NORTHWEST TERRITORIES

Seven lode gold mines operated in the Territories in 1968. Production for the year decreased by about 8.7 per cent compared with 1967. Tundra Gold Mines Limited exhausted all ore and suspended mining operations early in 1968. Discovery Mines Limited suffered a sharp decline in production. At the end of the year Discovery had limited ore reserves remaining and will be suspending mining operations in the first half of 1969. Production at Con mine of Cominco Ltd., Rycon Mines Limited which is controlled by Cominco and at Giant Yellowknife Mines Limited decreased in 1968. Vol Mines Limited which is worked through extensions of the Rycon and Con underground workings did not produce gold in 1968. Deep exploratory work is being carried out on the downward extension of the ore zone. Lolor Mines Limited and Supercrest Mines Limited, both contiguous to and controlled by Giant, recorded the first full year of production. The ore is mined through extensions of the Giant underground workings and treated at the Giant mill.

YUKON TERRITORY

Gold production in the Yukon increased in 1968 due to the copper mine of New Imperial Mines Ltd. recording its first full year of production. Gold recovered from placer operations declined by a small amount.

The silver-gold properties of Arctic Gold and Silver Mines Limited, near Carcross and Mount Nansen Mines Limited, near Carmacks, began production in the second half of the year. Arctic temporarily suspended milling operations in December.

NEW PROPERTY DEVELOPMENTS

QUEBEC

Eagle Gold Mines Limited in Joutel Township, northwestern Quebec, completed a shaft sinking program to 1,860 feet and was carrying out a lateral development program to explore the gold and copper-gold zones.

ONTARIO

Robin Red Lake Mines Limited resumed underground exploration and development in 1968 on its gold property in the Red Lake area. The work is being carried out by Dickenson Mines Limited through extensions of the workings from its adjoining gold mine. The program is being financed by Dickenson, Dome and Noranda Mines Limited.

MANITOBA

Agassiz Mines Limited, near Lynn Lake, completed sinking a shaft to a depth of 450 feet and was crosscutting on two levels at year-end to investigate the ore zones.

NORTHWEST TERRITORIES

In the Yellowknife area, Cominco under an agreement with Yellorex Mines Limited, is carrying out an exploration and development program on the adjoining property of Yellorex to the south by extending the workings on Con mines 2,300-foot level into the Yellorex ground.

TABLE 3

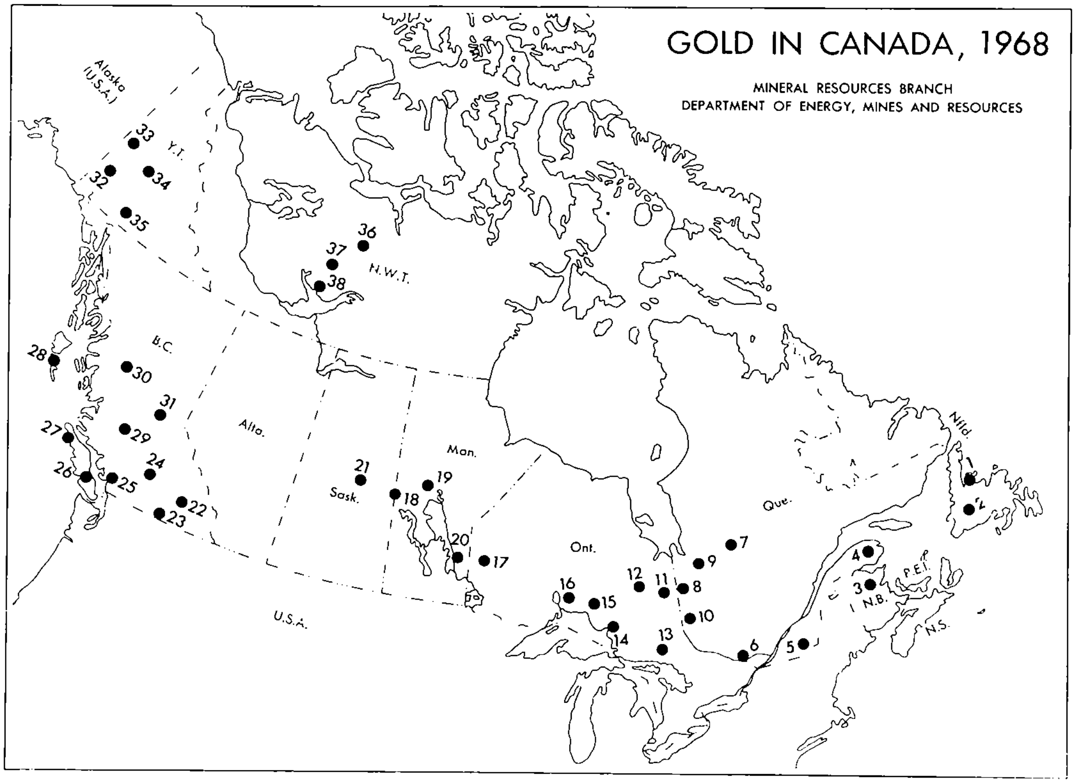
Canada - Gold Production, 1959-68p

	Auriferous Quartz Mines		Placer Operations		Base-Metal Ores		Total	
	Troy Ounces	Per Cent	Troy Ounces	Per Cent	Troy Ounces	Per Cent	Troy Ounces	Per Cent
1959	3,852,074	85.9	72,974	1.6	558,368	12.5	4,483,416	100.0
1960	3,930,366	84.9	80,804	1.7	617,741	13.4	4,628,911	100.0
1961	3,774,522	84.4	69,240	1.5	629,937	14.1	4,473,699	100.0
1962	3,494,821	83.6	57,760	1.4	625,815	15.0	4,178,396	100.0
1963	3,324,907	83.1	57,905	1.4	620,315	15.5	4,003,127	100.0
1964	3,151,593	82.2	58,512	1.5	625,349	16.3	3,835,454	100.0
1965	2,958,874	82.1	44,598	1.2	602,559	16.7	3,606,031	100.0
1966	2,676,381	80.6	43,369	1.3	599,724	18.1	3,319,474	100.0
1967	2,426,137	81.2	9,411	0.3	550,720	18.5	2,986,268	100.0
1968p	2,207,533	80.3	8,457	0.3	532,343	19.4	2,748,333	100.0

Canada - Gold Production, Average Value per Ounce
and Relationship to Total Value
All Mineral Production, 1959-68p

	Total Production (troy ounces)	Total Value ($ Cdn.)	Average Value per Ounce ($ Cdn.)	Gold as a % of Total Value of Mineral Production
1959	4,483,416	150,508,275	33.57	6.2
1960	4,628,911	157,151,527	33.95	6.3
1961	4,473,699	158,637,366	35.46	6.1
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	3.6
1966	3,319,474	125,177,364	37.71	3.1
1967	2,986,268	112,731,618	37.75	2.6
1968p	2,748,333	103,639,636	37.71	2.2

Source: Dominion Bureau of Statistics.
pPreliminary.



GOLD PRODUCERS, 1968

(numbers refer to numbers on the map)

NEWFOUNDLAND

1 Atlantic Coast Copper Corporation Limited (a)
Consolidated Rambler Mines Limited (a)
2 American Smelting and Refining Company (Buchans Unit) (a)

NEW BRUNSWICK

3 Cominco Ltd. (Wedge Mine) (a)
Heath Steele Mines Limited (a)

QUEBEC

4 Gaspé Copper Mines, Limited (a)
5 Solbec Copper Mines, Ltd. (a)
Cupra Mines Ltd. (a)
6 New Calumet Mines Limited (a)
7 Chibougamau District
Campbell Chibougamau Mines Ltd. (a)
Merrill Island Mining Corporation, Ltd. (a)
Norbeau Mines (Quebec) Limited (b)
Opemiska Copper Mines (Quebec) Limited (a)
The Patino Mining Corporation (Copper Rand Mines Division) (a)
8 Noranda – Rouyn District
Lake Dufault Mines, Limited (a)
Noranda Mines Limited (a)
Quemont Mines Limited (a)
Wasamac Mines Limited (Shaft No. 1) (b)
Wasamac Mines Limited (Shaft No. 2) (b)
Malartic District
Barnat Mines Ltd. (b)
Camflo Mines Limited (b)
East Malartic Mines, Limited (b)
Little Long Lac Gold Mines Limited, The (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
Normetal Mines Limited (a)
9 Matagami District
Mattagami Lake Mines Limited (a)
New Hosco Mines Limited (a)
Orchan Mines Limited (a)
10 Belleterre District
Lorraine Mining Company Limited (a)

ONTARIO

11 Larder – Lake District
Kerr Addison Mines Limited (b)
Kirkland Lake District
Lamaque Mining Company Limited (Teck-Hughes Mining Division) (b)
Macassa Gold Mines Limited (b)
Upper Beaver Mines Limited (a)
Upper Canada Mines, Limited (b)
12 Porcupine District
Aunor Gold Mines Limited (b)
Dome Mines Limited (b)
Hallnor Mines, Limited (b)
Hollinger Mines Limited (Hollinger) (b)
Hollinger Mines Limited (Ross) (b)
McIntyre Porcupine Mines Limited (a) (b)
Pamour Porcupine Mines, Limited (b)
Preston Mines Limited (b)
13 Sudbury Mining Division
Falconbridge Nickel Mines, Limited (a)
The International Nickel Company of Canada, Limited (a)
14 Renabie Mines Limited (b)
Sault Ste. Marie Mining Division
Surluga Gold Mines Limited (b)
15 Thunder Bay Mining Division
Noranda Mines Limited (Geco Mine) (a)
16 MacLeod Mosher Gold Mines Limited (b)
17 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)
Wilmar Mines Limited (b)

MANITOBA

18 Hudson Bay Mining and Smelting Co., Limited (a)
19 Hudson Bay Mining and Smelting Co., Limited (Snow Lake) (a)
The International Nickel Company of Canada, Limited (Thompson Mine) (a)
20 San Antonio Gold Mines Limited (b)

SASKATCHEWAN

18 Hudson Bay Mining and Smelting Co., Limited (a)
21 Anglo-Rouyn Mines Limited (a)

BRITISH COLUMBIA

22 Cominco Ltd. (a)
23 The Granby Mining Company Limited (Phoenix Copper Division) (a)
24 Bethlehem Copper Corporation Ltd. (a)
25 The Anaconda Company (Canada) Ltd., (Britannia Mine) (a)
Texada Mines Ltd. (a)
26 Western Mines Limited (a)
27 Coast Copper Company, Limited (a)
28 Wesfrob Mines Limited (a)
29 Bralorne Pioneer Mines Limited (b)
30 Granisle Copper Limited (b)
31 Small placer operations (c)

YUKON TERRITORY

32 Small placer operations (c)
33 Small placer operations (c)
34 Small placer operations (c)
35 New Imperial Mines Ltd. (a)
Arctic Gold and Silver Mines Limited (d)

NORTHWEST TERRITORIES

36 Tundra Gold Mines Limited (b)
37 Discovery Mines Limited (b)
38 Cominco Ltd. (Con and Rycon Mines) (b)
Giant Yellowknife Mines Limited (b)
Lolor Mines Limited (b)
Supercrest Mines Limited (b)

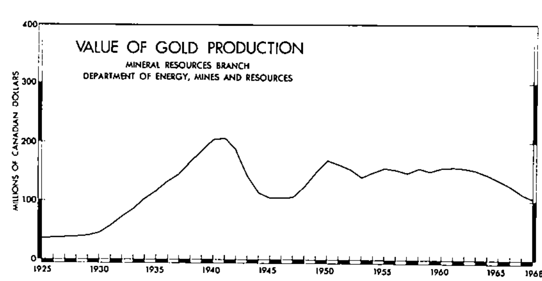
(a)Base metal; (b)Auriferous quartz; (c)Placer; (d)Silver-gold.

USES

Gold is used as a monetary reserve by governments and central banks to assist in the settlement of international trade balances.

The demand for gold for industry and the decorative arts has greatly increased in recent years. The International Monetary Fund in its annual report for 1968 estimated that the value of gold consumed in the world for industrial and artistic purposes increased from $560 million US funds in 1965 to $725 million in 1966 and to $805 million in 1967.

Over 70 per cent of the industrial use for gold is in the manufacture of jewellery and objects of art. Dentistry is a major consumer of gold. The remainder is consumed in the electrical, electronic, chemical, computer and glass making fields and in various aerospace applications.



PRICES

The average price paid by the Royal Canadian Mint in 1968 was $37.71 per fine ounce. This compares with $37.75 in 1967 and $37.71 in 1966. During 1968 the price fluctuated between a low of $37.54 and a high of $38.06. The fixed value of the Canadian dollar is $0.925 in terms of United States funds but a variation of one per cent either way is permitted. As a result of this tolerance, the Mint gold price could range from $37.46 to $38.22 per fine ounce.

A heavy demand for nonmonetary gold, especially after the devaluation of the pound late in 1967, led to the closing of the London gold market on March 15, 1968. The governors of the central banks of the seven countries belonging to the Gold-Pool met on March 16 and 17, 1968 to discuss the operation of the Gold-Pool and problems of international exchange. The results of these discussions led to the establishment of the two-tier price system for gold. The governors agreed that the existing official gold reserves would be used only in the transfers among monetary authorities at the established price of $35 US a troy ounce and that the central banks would neither purchase nor sell gold in private gold markets. Gold used in industry would have to be bought in the open market. Source of supply would be newly mined gold and/or release of gold stocks held by hoarders and speculators. The price would be subject to fluctuations depending on supply and demand.

The establishment of the two-tier price system did not affect the sale of gold by Canadian mines. Producers can continue to sell in the free market. Producers who qualify for assistance under the provisions of the Emergency Gold Mining Assistance Act continue to sell to the Royal Canadian Mint as is required by the Act. The Mint buys the gold at $35 US per troy ounce converted into Canadian dollars at current exchange rates. Gold purchased by the Mint is sold in the free market.

The London gold market resumed trading on April 1, 1968 and the price varied from a low of $36.70 US a troy ounce in April to a high of $42.60 US in May.

Gypsum and Anhydrite

R. K. COLLINGS*

Following three years of declining production as a result of reduced activity in the building construction industry, gypsum production in 1968 rose 19 per cent over 1967 to 6.1 million tons, valued at $13.1 million. This increase reflects increased building activity not only in Canada but in the United States, as well, the latter being a major market for Canadian gypsum. Housing starts rose 20 per cent in Canada to 196,878 in 1968, and 14 per cent in the United States to 1.5 million. Exports of crude gypsum to the United States, at 4.5 million tons, were 14½ per cent higher than the previous year and represented over 70 per cent of the total Canadian production in 1968. Imports of crude gypsum, mostly from Mexico to support a gypsum-products plant in the Vancouver area, at 69,062 tons, were about the same as in 1967. Imports of gypsum products also showed little change.

OCCURRENCES

Canada has large, well-located, gypsum deposits – many containing gypsum of high purity. Deposits occur in all provinces except Prince Edward Island and Saskatchewan.

Although many domestic gypsum deposits are well located and contain adequate reserves, those in some areas, notably Quebec, Alberta and to a lesser degree, British Columbia, are more remote and often smaller. The two gypsum-products plants in Montreal bring in crude from Nova Scotia, a Saskatchewan plant obtains crude from Manitoba, and the two plants in Calgary obtain crude from British Columbia and Manitoba. Although gypsum deposits occur in Alberta, several of the more promising deposits are in national parks and are not available for mining. One of the two gypsum-products plants in Vancouver obtains gypsum from a company-operated quarry in the southeastern part of British Columbia; the other imports its requirements from Mexico. The gypsum deposits in southeastern British Columbia are extensive but, although fairly close to the Calgary market, are distant from Vancouver. High transportation costs have to date deterred wider development of these deposits.

Large surface and near-surface gypsum deposits occur in three of the Atlantic Provinces: in Nova Scotia, throughout the central and northern parts of the mainland and in Cape Breton Island; in the St. George's Bay area of southwestern Newfoundland; and in southeastern New Brunswick near Hillsborough.

No gypsum occurrences are known in mainland Quebec but deposits outcrop over large areas of the Magdalen Islands in the Gulf of St. Lawrence.

In Ontario, gypsum occurs in the Moose River area, south of James Bay, and in the Grand River area, south of Hamilton. The Moose River deposits are 15 to 20 feet thick and usually covered by 10 to 30 feet of overburden; the Grand River deposits occur at depths up to 200 feet and are generally thin.

Manitoba and Alberta have large gypsum deposits. The main occurrences in Manitoba are in the southern section of the province at Gypsumville, where a 30-foot thickness of gypsum is exposed; near Amaranth where 40 feet of gypsum with interbedded anhydrite occurs below 100 feet; and at Silver Plains,

*Mineral Processing Division, Mines Branch.

30 miles south of Winnipeg, where gypsum occurs 140 feet below the surface. Gypsum occurs in Alberta in Wood Buffalo Park and is exposed along the banks of the Peace River between Peace Point and Little Rapids. It also is present along the banks of the Slave and Salt rivers north and west of Fort Fitzgerald. In addition, outcrops of gypsum have been found near Mowitch Creek, within the northern boundary of Jasper Park, and at the headwaters of Fetherstonhaugh Creek, near the Alberta-British Columbia border.

In British Columbia, deposits occur at Windermere, Mayook and Canal Flats, in the southeast; at Falkland near Kamloops; and near Loos in the east-central part.

Gypsum deposits have been found in the southern part of Yukon Territories, along the north shore of Great Slave Lake, along the banks of the Mackenzie, Great Bear and Slave rivers, and on several of the Arctic islands.

The rapid expansion of Canada's phosphate fertilizer industry is resulting in the accumulation of

TABLE 1

Canada – Gypsum – Production and Trade, 1967-68

	1967		1968P	
	Short Tons	$	Short Tons	$
Production (shipments)				
Crude gypsum				
Nova Scotia	3,757,329	7,798,930	4,451,500	8,961,950
Ontario	536,375	1,268,365	742,366	1,745,400
Newfoundland	439,156	1,068,604	454,955	1,091,392
British Columbia	219,986	615,961	250,000	700,000
Manitoba	133,897	414,491	159,980	485,000
New Brunswick	88,641	182,000	86,392	175,000
Total	5,175,384	11,348,351	6,145,193	13,158,742
Imports				
Crude gypsum				
Mexico	64,500	283,000	67,966	264,000
United States	4,575	42,000	1,092	17,000
Britain	37	2,000	4	...
Total	69,112	327,000	69,062	281,000
Plaster of paris and wall plaster				
United States	9,552	517,000	7,678	507,000
Britain	304	14,000	380	16,000
Other countries	14	2,000	–	–
Total	9,870	533,000	8,058	523,000
Gypsum lath, wallboard and basic products				
United States	434	30,000	396	36,000
Britain	–	–	12	1,000
Total	434	30,000	408	37,000
Total imports gypsum and gypsum products	79,416	890,000	77,528	841,000
Exports				
Crude gypsum				
United States	3,896,128	7,323,000	4,463,605	8,332,000
Other countries	6	...	–	–
Total	3,896,134	7,323,000	4,463,605	8,332,000

Source: Dominion Bureau of Statistics.
PPreliminary; – Nil; ... Less than one thousand dollars.

TABLE 2

Gypsum Production, Trade and Consumption, 1959-68
(short tons)

	Production[1]	Imports[2]	Exports[2]	Apparent Consumption[3]
1959	5,878,630	117,830	4,848,576	1,147,884
1960	5,205,731	60,011	4,273,668	992,074
1961	4,940,037	66,075	3,819,345	1,186,767
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
1968p	6,145,193	69,062	4,463,605	1,750,650

Source: Dominion Bureau of Statistics.
[1]Producers' shipments, crude gypsum. [2]Includes crude and ground, but not calcined. [3]Production plus imports minus exports.
pPreliminary.

TABLE 3

World Production of Gypsum,1967-68
(thousand short tons)

	1967	1968e
United States	9,393	10,100
France	5,512	5,600
Canada	5,175	6,145
Britain	4,950	5,000
Communist countries (except Yugoslavia)	7,266	7,500
Spain	..	..
Italy	3,638	4,000
Other countries	17,066	16,655
Total	53,000	55,000

Source: U.S. Bureau of Mines, Commodity Data Summaries, January, 1969.
eEstimated; .. Not available.

large tonnages of byproduct, synthetic gypsum. Produced during the manufacture of phosphoric acid and phosphate rock, this gypsum is finely divided and relatively impure. It is now produced in British Columbia, Alberta, Manitoba, Ontario, Quebec and New Brunswick. Production currently exceeds 2 million tons per year. Although essentially a waste material in Canada and the United States, byproduct, synthetic gypsum is used for gypsum products manufacture in Japan, Britain and Germany. This material would be of interest where there are no natural gypsum deposits or where deposits are of poor quality and in such areas should be investigated as a possible source material for gypsum-products manufacture. It is also of interest as a potential source of sulphur.

CURRENT OPERATIONS

NOVA SCOTIA

There are five companies actively producing gypsum in Nova Scotia. Production totalled 4.4 million tons in 1968, 72 per cent of the Canadian total. Over 90 per cent of the production of this province is exported to the United States.

Fundy Gypsum Company Limited, a subsidiary of United States Gypsum Company of Chicago, quarries gypsum for export at Wentworth and Miller Creek, near Windsor. National Gypsum (Canada) Ltd., a subsidiary of National Gypsum Company of Buffalo, New York, quarries gypsum near Milford, 30 miles north of Halifax. Most is exported to company plants in the United States; however, some is used in Nova Scotia in cement manufacture and in Quebec in cement and gypsum products. Gypsum for export is also obtained at Walton, Hants County. Little Narrows Gypsum Company Limited, also a subsidiary of United States Gypsum Company, quarries gypsum at Little Narrows on Cape Breton Island, shipping crude rock to the United States and to Quebec and Ontario.

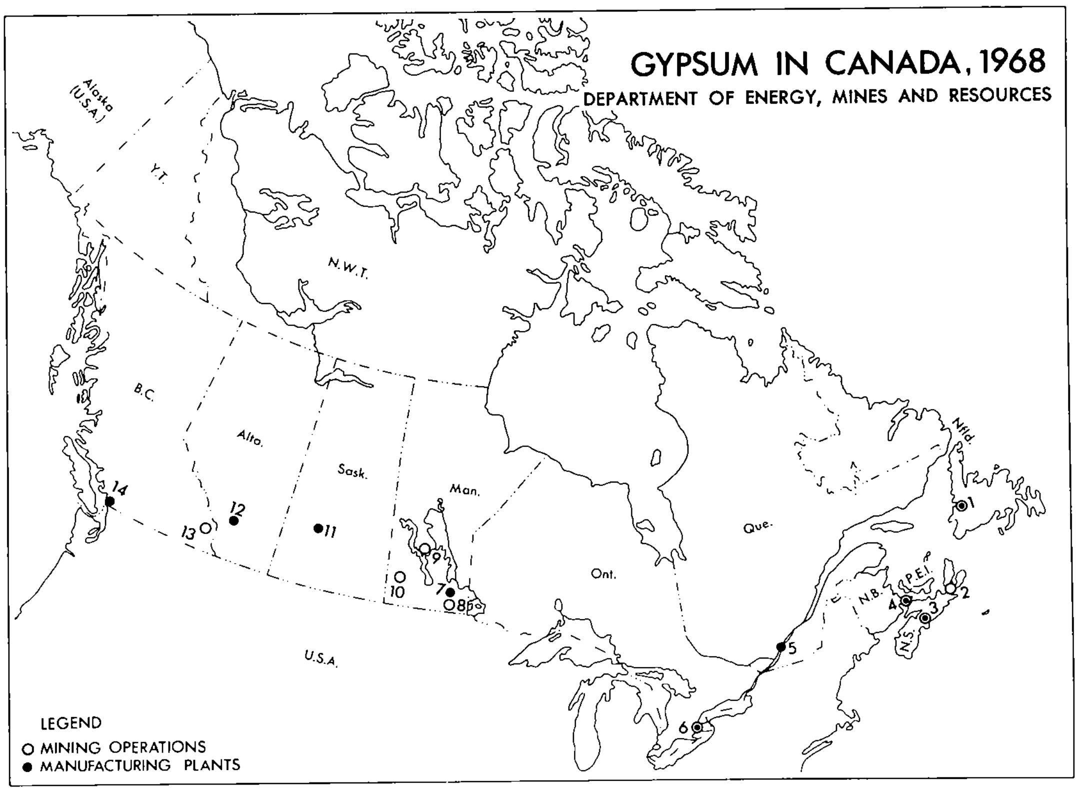
Domtar Construction Materials Ltd., with head offices in Montreal, operates a calcining plant at Windsor for the production of plaster of paris. Gypsum for this plant is obtained from deposits at McKay Settlement near Windsor. Georgia-Pacific Corporation, Bestwall Gypsum Division, quarries gypsum near River Denys, Inverness County. The crushed rock is carried by rail to Point Tupper, 20 miles from the quarry site, for shipment to the United States.

ONTARIO

Gypsum is mined from underground deposits at Caledonia, near Hamilton, by Domtar Construction Materials Ltd., and at Hagersville, southwest of Caledonia, by Canadian Gypsum Company, Limited. It is used in the manufacture of plaster and wallboard at company plants located near each mine.

NEWFOUNDLAND

Atlantic Gypsum Limited produces gypsum plaster and wallboard at Humbermouth, on the west coast of the island. This plant is managed by Lundrigans Limited of St. John's. Crude gypsum is obtained from deposits at Flat Bay Station, 60 miles southwest of Humbermouth, which are quarried by The Flintkote Company of Canada Limited. The bulk of the



MINING OPERATIONS*

(numbers refer to numbers on map)

1. The Flintkote Company of Canada Limited, Flat Bay Station
2. Little Narrows Gypsum Company Limited, Little Narrows
   Georgia-Pacific Corporation, Bestwall Gypsum Division, River Denys
3. Fundy Gypsum Company Limited, Wentworth and Miller Creek
   National Gypsum (Canada) Ltd., Milford and Walton
   Domtar Construction Materials Ltd., McKay Settlement
4. Canadian Gypsum Company, Limited, Hillsborough
6. Canadian Gypsum Company, Limited, Hagersville (underground)
   Domtar Construction Materials Ltd., Caledonia (underground)
8. Western Gypsum Limited, Silver Plains (underground)
9. Domtar Construction Materials Ltd., Gypsumville
10. BACM Industries Limited, Amaranth
13. Western Gypsum Mines Ltd., Windermere

MANUFACTURING PLANTS

1. Atlantic Gypsum Limited, Humbermouth
3. Domtar Construction Materials Ltd., Windsor
4. Canadian Gypsum Company, Limited, Hillsborough
5. Canadian Gypsum Company, Limited, Montreal
   Domtar Construction Materials Ltd., Montreal
6. Canadian Gypsum Company, Limited, Hagersville
   Domtar Construction Materials Ltd., Caledonia
   Western Gypsum Limited, Clarkson
7. Domtar Construction Materials Ltd., Winnipeg
   Western Gypsum Limited, Winnipeg
11. BACM Industries Limited, Saskatoon
12. Domtar Construction Materials Ltd., Calgary
    Western Gypsum Limited, Calgary
14. Domtar Construction Materials Ltd., Port Mann
    Western Gypsum Limited, Vancouver

*Surface operations except where noted otherwise.

production from Flat Bay is transported by aerial conveyor to St. George's, 6 miles distant, where it is loaded on boats for export to company plants along the eastern coast of the United States. Part of the production is shipped to markets in Ontario and Quebec.

BRITISH COLUMBIA

Western Gypsum Mines Ltd., a subsidiary of Western Gypsum Limited, quarries gypsum near Windermere in the southeastern part of the province. The gypsum is shipped to company plants in Calgary and Vancouver and to Domtar Construction Materials Ltd. for use in its Calgary plant. Windermere gypsum is also used by cement plants in Alberta and British Columbia.

MANITOBA

Gypsum is quarried at Gypsumville, 150 miles northwest of Winnipeg, by Domtar Construction Materials Ltd. This gypsum is used at Winnipeg and Calgary for plaster and wallboard manufacture at company-owned plants.

Western Gypsum Limited obtains gypsum from an underground deposit near Silver Plains, 30 miles south of Winnipeg, for use in company-owned gypsum-products plants in Winnipeg and Calgary. The deposit is 140 feet below the surface.

BACM Industries Limited obtains gypsum from a deposit at Amaranth for use in a gypsum-products plant at Saskatoon. The seam mined is 125 feet below the surface.

NEW BRUNSWICK

Gypsum is quarried near Hillsborough by Canadian Gypsum Company, Limited, for plaster and wallboard manufacture at a company-owned plant at Hillsborough. Canada Cement Company, Limited, obtains gypsum from Havelock, west of Moncton, for cement manufacture at Havelock.

USES

Gypsum, hydrous calcium sulphate ($CaSO_4.2H_2O$), is chiefly used for the production of calcined gypsum, or plaster of paris, which in turn is the main constituent used in manufacturing gypsum board and lath, gypsum tile and roof slabs, and all types of industrial plasters. Plaster of paris is mixed with water and aggregate (sand, vermiculite or expanded perlite) and applied over wood, metal or gypsum lath to form an interior wall finish. Gypsum board, lath and sheathing are formed by introducing a slurry consisting of plaster of paris, water, foam, accelerator, etc., between two sheets of absorbent paper, where it sets, producing a firm, strong wallboard.

Crude uncalcined gypsum is used in the manufacture of portland cement. The gypsum acts as a retarder to control set. Reduced to 100 mesh or finer, crude gypsum is used as a filler in paint and paper. Ground gypsum is used to a small extent as a substitute for salt cake in glass manufacture. Powdered gypsum improves alkaline soils; aids in restoring impervious, dispersed soil; and is a fertilizer for peanuts.

ANHYDRITE*

Anhydrite, anhydrous calcium sulphate ($CaSO_4$), is commonly associated with gypsum. It is produced in Nova Scotia by Fundy Gypsum Company Limited at Wentworth; by Little Narrows Gypsum Company Limited at Little Narrows; and for National Gypsum (Canada) Ltd. by B.A. Parsons at Walton.

Production in 1967 was about 250,000 tons. Most of this was shipped to the United States for use in portland cement manufacture and as a fertilizer for peanut crops. Anhydrite also has a small application as a soil conditioner.

Gypsum and anhydrite are potential sources of sulphur compounds but are not utilized as such in Canada. In Europe, gypsum or anhydrite is calcined at a high temperature with coke, silica and clay to produce sulphur dioxide, sulphur trioxide and co-product cement. The gases are then converted into sulphuric acid.

TARIFFS*

	British Preferential (%)	Most Favoured Nation (%)	General (%)
CANADA			
Gypsum, crude	free	free	free
Gypsum, ground, not calcined	6	7½	15
Gypsum wallboard and lath	15	19	35
Plaster of paris and prepared wall plaster, per 100 lb	free	9¢	12-½¢
UNITED STATES			
Gypsum, crude	free		
Gypsum, ground or calcined per long ton	\$0.95		
Gypsum wallboard and lath	10%		

*January 1, 1969.

Sources: The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa.

Tariff Schedules of the United States Annotated (1969) TC Publication 272.

*Production and trade statistics for anhydrite are not reported separately by the Dominion Bureau of Statistics but are included with gypsum in the gypsum section of this review.

Indium

ROBERT J. SHANK*

Indium occurs widely in nature, usually in minute quantities and never in the native state. It is found principally in the ores of zinc with lesser amounts found in lead, iron and copper ores. Being most commonly associated with sphalerite, the predominant zinc mineral, indium becomes concentrated in certain residues and slags formed during zinc and lead smelting operations. Painstaking metallurgical procedures are followed in recovering high purity indium suitable for industrial needs from these residues and slags. Only a few of the world's zinc and lead smelters recover indium.

Statistics on the production of indium are not available. Cominco Ltd., the only producer in Canada, recovers indium from zinc and lead metallurgical operations at Trail, British Columbia, and is one of the world's largest producers. Indium is recovered by two companies in the United States; it is recovered also in Peru, West Germany, Japan and USSR.

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 grades (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 disks, 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

*Mineral Resources Branch.

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 of 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 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, 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.

A newer use of indium, probably the most extensive now, is found in various semiconductor devices. In these, high-purity indium alloyed in the form of disks 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 intermetallic semiconductors, 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. It is also used in neutron monitoring badges. Indium compounds added to lubricants have been found to have a beneficial anticorrosive effect. Indium is used in certain very small lightweight batteries.

TRADE AND CONSUMPTION

No statistics are available on export, import or domestic consumption of indium. Much of Canada's output is exported to the United States and Britain, and smaller amounts go to a number of countries in Europe.

PRICES

Prices of indium as quoted in *Metals Week*, which had been unchanged since October 5, 1965, were reduced on September 19, 1968 by 25 cents a troy ounce. This price decline was attributed to weakness in the United States market due to heavy imports, primarily from Japan.

Prices were as follows:

	October 5, 1965 to September 18, 1968	September 19, 1968 to Year-end
Sticks, 30-90 troy oz	\$2.75 a troy oz	\$2.50 a troy oz
Ingot – 100 troy oz	\$2.30 a troy oz	\$2.05 a troy oz
10,000+ troy oz	\$2.00 a troy oz	\$1.75 a troy oz

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 in some countries with reductions beginning on January 1, 1968, and final reductions occurring on January 1, 1972.

Iron Ore

V.B. SCHNEIDER*

Canadian iron ore shipments increased for the seventh consecutive year in 1968 and reached an all-time high of 44,083,329 long tons** valued at $556 million. Exports also reached an all-time high of 36 million tons, an increase of 11½ per cent from the previous high of 31.4 million tons in 1967. Shipments from Newfoundland, Quebec and Ontario increased and those from British Columbia decreased slightly. Domestic consumption of iron ore was 10.7 million tons of which 8.1 million tons came from Canadian mines and 2.6 million tons from imports. Of the imports, 2.3 million tons came from the United States. This reflects the participation by the domestic steel industry in United States iron ore mines; a participation that predates the current iron ore industry in Canada.

Two new mines, the Sherman Mine and The Griffith Mine, both in Ontario, began shipments of pellets in 1968. Wabush Mines completed an expansion program that increased pellet producing capacity from 4.9 million tons a year to 6 million tons a year, and Iron Ore Company of Canada (IOC) began construction of a new $13 million dock and loading facilities, that will be able to load ships up to 200,000 tons at a rate of 15,000 tons an hour. In British Columbia, Jedway Iron Ore Limited and Brynnor Mines Limited ceased production in 1968.

Annual iron ore production capacity in Canada at the end of 1968 was 47 million tons, which included 24.83 million tons of pellet capacity. Production in 1968 came from 19 companies; six concentrate-producers in British Columbia, eight in Ontario of which seven produced pellets and one sinter, two in Quebec of which one produced pellets and one concentrate, one direct-shipping ore producer in Quebec-Newfoundland and two pellet producers in Labrador. In addition to the 19 iron ore and pellet producing companies four other companies recovered byproduct iron in 1968. They were, Cominco Ltd., which produces about 150,000 tons annually of oxide sinter from pyrrhotite flotation concentrates at Kimberley, British Columbia; Falconbridge Nickel Mines, Limited which produces from 60,000 to 90,000 tons annually of calcine from pyrrhotite flotation concentrate at Falconbridge, Ontario; The International Nickel Company of Canada, Limited, which produces about 700,000 tons of pellets a year from pyrrhotite flotation concentrates at Copper Cliff, Ontario; and Quebec Iron and Titanium Corporation, which recovers about 400,000 tons of pig iron a year from ilmenite at its smelter at Sorel, Quebec in the manufacture of TiO_2 slag.

Falconbridge Nickel Mines, Limited announced plans for the construction of a plant to produce reduced pellets that will contain 90 per cent iron and 1.5 per cent nickel. The plant will probably begin commercial operation at 300,000 tons annually late in 1969 or early 1970.

Iron Ore Company of Canada continued further test work on the beneficiation and pelletizing of standard ores from its mine at Schefferville and the company is making preliminary engineering and cost estimates for a commercial plant of up to 6 million tons annual capacity. The success of this operation would make Schefferville ore competitive for a good many years. It is currently being marketed as a direct-shipping ore with about 53 per cent iron.

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*Mineral Resources Branch.

**The long or gross ton (2,240 pounds) is used throughout unless otherwise noted.

TABLE 1

Canada, Iron Ore Production and Trade, 1967-68

	1967		1968p	
	Long Tons	$	Long Tons	$
Production (shipments)				
Newfoundland	15,162,113	207,408,843	18,676,767	262,501,000
Quebec	12,975,024	141,814,861	13,935,034	145,133,551
Ontario	7,723,003	99,903,925	9,619,206	127,923,747
British Columbia	1,923,609	20,994,056	1,852,322	20,354,221
Total	37,783,749	470,121,685	44,083,329	555,912,519
Byproduct iron ore*	904,900	. .	802,100e	. .
Imports				
Iron ore				
United States	2,247,349	31,484,000	2,297,800	30,465,000
Brazil	108,609	1,062,000	373,100	3,536,000
Liberia	44,711	323,000	76,936	593,000
Australia	–	–	1,752	17,000
Total	2,400,669	32,869,000	2,749,588	34,611,000
Exports				
Iron ore, direct shipping				
United States	6,017,640	62,675,000	5,623,769	55,757,000
Italy	525,038	4,888,000	457,060	2,907,000
Britain	14,777	142,000	301,268	2,878,000
Belgium and Luxembourg	–	–	69,419	677,000
Total	6,557,455	67,705,000	6,451,516	62,219,000
Iron ore concentrates				
United States	7,886,771	84,059,000	8,558,296	92,571,000
Japan	1,631,299	17,291,000	1,862,169	19,045,000
Britain	1,889,526	17,278,000	1,843,978	16,331,000
Netherlands	763,474	7,804,000	702,460	5,112,000
West Germany	86,097	627,000	481,012	3,210,000
Italy	249,571	1,837,000	68,974	480,000
Finland	–	–	18,328	127,000
Bahamas	5,000	46,000	–	–
Total	12,511,738	128,942,000	13,535,217	136,876,000
Iron ore, agglomerated				
United States	9,176,244	138,629,000	11,992,246	182,540,000
Britain	961,687	14,406,000	1,205,920	18,377,000
Italy	864,660	12,963,000	820,092	12,664,000
West Germany	416,820	6,208,000	809,730	12,195,000
Netherlands	495,320	7,370,000	529,741	7,978,000
Belgium and Luxembourg	–	–	89,972	1,380,000
Japan	–	–	28,810	434,000
Total	11,914,731	179,576,000	15,476,511	235,568,000
Iron ore, not elsewhere specified including byproduct iron ore				
United States	422,528	6,838,000	512,355	8,466,000
West Germany	78	1,000	35,119	72,000
Total	422,606	6,839,000	547,474	8,538,000

TABLE 1 (Cont'd)

	1967		1968p	
	Long Tons	$	Long Tons	$
Total export all classes				
United States	23,503,183	292,201,000	26,686,666	339,334,000
Britain	2,865,990	31,826,000	3,351,166	37,586,000
Japan	1,631,299	17,291,000	1,890,979	19,479,000
Italy	1,639,269	19,688,000	1,346,126	16,051,000
West Germany	502,995	6,836,000	1,325,861	15,477,000
Netherlands	1,258,794	15,174,000	1,232,201	13,090,000
Belgium and Luxembourg	–	–	159,391	2,057,000
Finland	–	–	18,328	127,000
Bahamas	5,000	46,000	–	–
Total	31,406,530	383,062,000	36,010,718	443,201,000

Source: Dominion Bureau of Statistics.

*Total shipments of byproduct iron ore compiled by Mineral Resources Branch from data supplied by individual companies. Total iron ore shipments include shipments of byproduct iron ore.

pPreliminary; . . Not available; eEstimated; – Nil.

CANADIAN DEVELOPMENTS IN 1968

NEWFOUNDLAND AND LABRADOR

Iron Ore Company of Canada (IOC), Labrador City: Shipments in 1968 of Carol Pellets amounted to 9.1 million tons and shipments of Carol Concentrates amounted to 0.9 million tons. This was the first full year of operation at its newly designed capacity of 10 million tons a year. In order to produce 11.6 million tons of concentrates at the Carol Operation, 24 million tons of ore were mined by open-pit methods at the IOC's nearby mine.

Wabush Mines (Scully Mine): An expansion program that was started in 1967 to increase annual capacity from 5 million tons of concentrates to 6 million tons was completed during 1968. By the end of the year the concentrator at Wabush, Labrador and the pellet plant at Pointe Noire, Quebec were operating at rated capacity. In 1968, 5.3 million tons of concentrate were produced from 16.1 million tons of crude ore mined by open-pit methods. The concentrate is shipped south to the company's pellet plant at Pointe Noire. Shipments from Pointe Noire in 1968 amounted to 5.4 million tons of pellets and 83,641 tons of concentrate.

The Mining Division, Department of Mines, Agriculture and Resources, Newfoundland and Labrador reported the sale of 448,960 tons of iron ore from Wabana Mines stockpile during 1968; about 100,000 tons are available for shipment in 1969.

LABRADOR-QUEBEC

Iron Ore Company, Schefferville: IOC operated five open-pit mines in the Schefferville area, of which one was in Labrador and four were in Quebec. The mines produce direct shipping ore. Shipments of Schefferville ore from the company's loading terminal at Sept-Iles amounted to 6.5 million tons in 1968. IOC also began construction of one of the world's largest iron ore loading docks. It will cost $13 million and is expected to be in operation in the fall of 1969 and, with 60 feet of minimum water at dockside, will be able to handle super-carriers of up to 200,000 tons capacity. Its initial loading rate will be in the neighbourhood of 9,000 tons an hour and plans call for that to be increased to an ultimate capacity of 15,000 tons an hour.

QUEBEC

Quebec Cartier Mining Company: Quebec Cartier shipped 8.6 million tons of concentrates from its shipping site at Port Cartier. The company operates an open-pit mine and concentrator at Gagnon some 190 miles by rail north of Port Cartier. The company beneficiated some 18.6 million tons of crude ore grading 34.3 per cent Fe to produce 8.6 million tons of concentrate grading 64.6 per cent Fe.

The Hilton Mines: The Hilton Mine is owned jointly by The Steel Company of Canada, Limited.; Jones & Laughlin Steel Corporation ; and Pickands Mather & Co. The latter company is the managing agent for this operation. Shipments in 1968 were 635,991 tons of which 631,364 tons were pellets. The company's open-pit mine, concentrator and pellet plant is near Shawville, some 40 miles west of Ottawa, Ontario. Approximately 3.8 million tons of crude ore grading 32.1 per cent Fe were beneficiated to produce 875,000 tons of pellets grading 66.4 per cent Fe.

TABLE 2

Canada, Iron Ore Production, Trade and Consumption 1959-68
(long tons)

	Production (shipments)	Imports	Exports	Consumption* (indicated)
1959	21,864,576	2,500,894	18,552,488	5,812,982
1960	19,241,813	4,514,596	16,942,140	6,814,269
1961	18,177,681	4,132,280	14,868,166	7,441,795
1962	24,428,282	4,604,819	21,645,758	7,387,343
1963	26,913,972	5,325,713	23,854,973	8,384,712
1964	34,219,484	5,233,434	30,473,701	8,979,217
1965	35,677,621	4,763,029	30,799,252	9,641,398
1966	36,331,003	4,323,121	30,693,745	9,960,379
1967r	37,783,749	2,400,669	31,406,530	8,777,888
1968p	44,083,329	2,749,588	36,010,718	10,822,199

Source: Dominion Bureau of Statistics.
*Shipments plus imports less exports with no account taken of changes in stocks at consuming plants.
p Preliminary; r Revised.

ONTARIO

Algoma Ore Division, The Algoma Steel Corporation, Limited: Algoma shipped 1,777,745 tons in 1968, nearly all sinter; about 1.6 million tons were shipped to Algoma Steel's plants in Canada and the balance was exported to the United States. The company produced some 2.9 million tons of crude ore grading 34.16 per cent iron in 1968, of which 2.3 million tons came from its George W. MacLeod underground mine and 0.6 million tons from its Ruth and Lucy open-pit mine, which attained production in commercial quantities in February 1968. Of the total crude mined, 4,587 tons were shipped to the United States for use as a food supplement in the livestock industry. The remaining tonnage was processed to make 1.7 million tons of sinter averaging 50.59 per cent iron.

A three-year option agreement dated December 1, 1968 was made with The Little Long Lac Gold Mines Limited covering an iron-formation on its claim near Geraldton, Ontario. Algoma could develop this property in conjunction with the Can-Fer property which it now has under option.

Caland Ore Company Limited: Caland shipped 1,202,738 tons of concentrates and 1,038,700 tons of pellets. Most of Caland's production went to its parent company, Inland Steel Company, in the United States. Crude ore grading 53.8 per cent Fe is mined by open-pit operations at the company's property at Steep Rock Lake, which it leased from Steep Rock Iron Mines Limited on a long-term basis. Ore was shipped as mined until 1965 when Caland completed its ore preparation and pelletizing facilities designed to produce 1.3 million tons of high quality screened ore and 1 million tons of pellets annually.

Adams Mine (Jones & Laughlin Mining Company, Ltd.): Adams Mine shipped 1,104,089 tons of pellets in 1968 which is an all-time high. The company operates an open-pit mine, concentrator and pelletizing plant just south of Kirkland Lake, Ontario. The company treated some 4.3 million tons of crude ore to produce 1.11 million tons of pellets. Most of the production is shipped by rail to the parent company's steel plants in the Pittsburgh, Pennsylvania area.

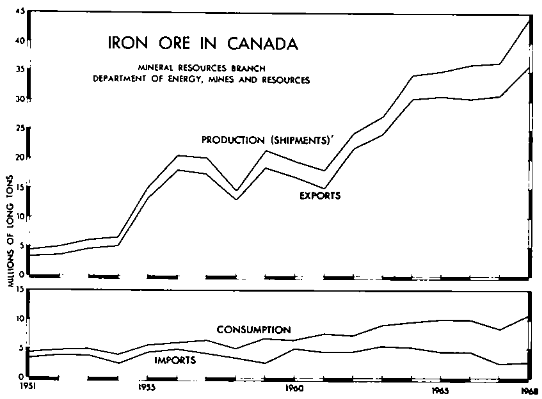
Marmoraton Mining Company, Division Bethlehem Chile Iron Mines Company: Marmoraton shipped 454,320 tons of pellets in 1968. The company operates an open-pit mine, concentrator and pelletizing plant near Marmora and a loading dock at Picton on the Bay of Quinte, Ontario. Some 1.03 million tons of crude ore were treated; 325,169 tons were rejected at the crushing operation and 828,563 tons of ore were beneficiated to produce 472,412 tons of concentrate containing 66.76 per cent Fe, which in turn was pelletized. Most of the company's production is shipped by rail to Picton and from Picton by boat to the company's steel works at Lackawanna, New York.

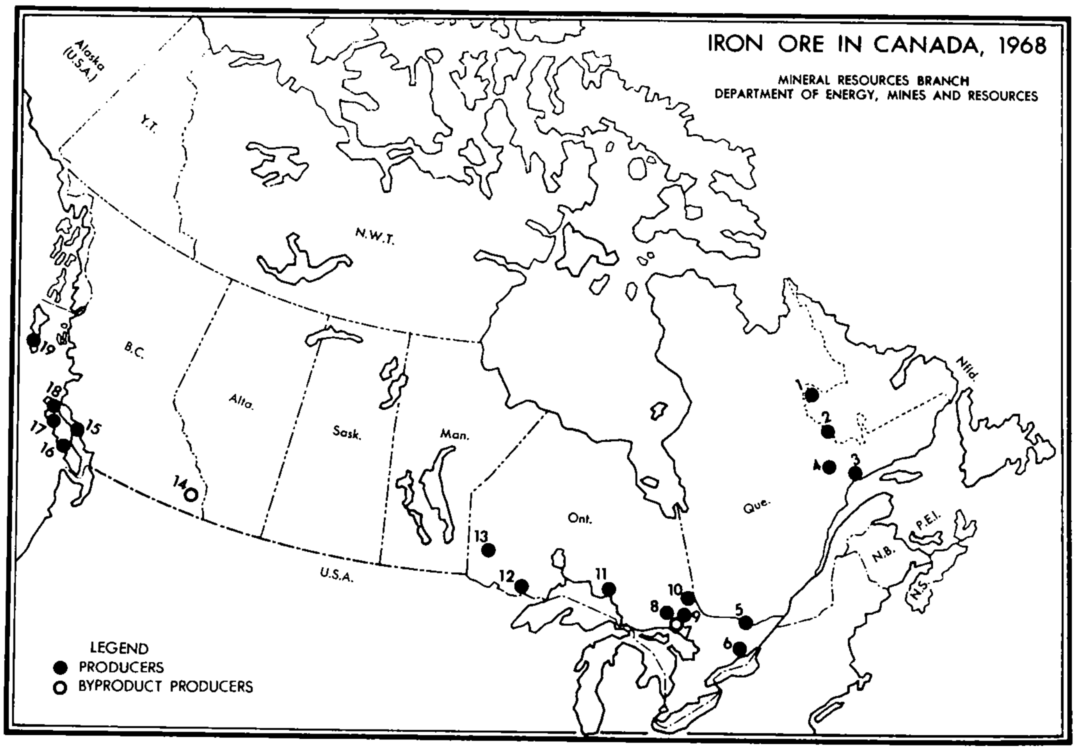
National Steel Corporation of Canada, Limited (Moose Mountain Mine): Moose Mountain Mine shipped 679,710 tons of pellets in 1968. This was an all-time high for the company, which operates an open-pit mine, concentrator and pellet producing plant north of Capreol, and an ore loading dock at Depot Harbour, Ontario. Some 1.6 million tons of crude ore were beneficiated to produce 673,851 tons of pellets. All shipments are by rail to Depot Harbour, from there they are shipped by vessel to the company's steelmaking facilities at Detroit, Michigan; Buffalo, New York; and Wiarton, West Virginia.

Steep Rock Iron Mines Limited: Steep Rock shipped 1,057,650 tons of pellets and 242,350 tons of direct-shipping ore in 1968 from its open-pit mine, concentrator and pellet plant. This was the first complete year of production for the company's pellet plant, which began operations in September 1967. Built at a cost of $26 million, the plant has an annual rated capacity of 1.35 million tons. Pellet production for 1968 was slightly below anticipated volume but the plant is expected to produce at full capacity during 1969. Most of the company's production is shipped to The Algoma Steel Corporation, Limited's Sault Ste. Marie plant. Steep Rock's iron property in the Lake St. Joseph area of northwestern Ontario has sufficient ore reserves to produce 160 million tons of pellets.

The Griffith Mine (Stelco): Although the open-pit mine, concentrator and pellet producing plant, near Bruce Lake, were officially dedicated on June 17, the first shipment to Stelco's Hamilton, Ontario, steel plant was made on March 13. The plant, which cost $62 million, has an annual capacity of 1.5 million tons of pellets. Pellets are shipped by rail to Fort William, Ontario and from there by vessel to Hamilton. In 1968, shipments amounted to 500,752 tons. Some 2.2 million tons of crude ore grading 31 per cent Fe were beneficiated to produce 506,295 tons of pellets grading 64.35 per cent Fe.

The Sherman Mine (Dofasco): The Sherman Mine is a joint venture of Dominion Foundries and Steel, Limited and Tetapaga Mining Company Limited, a wholly-owned subsidiary of The Cleveland-Cliffs Iron





PRODUCERS

(numbers refer to numbers on map)

1. Iron Ore Company of Canada (Schefferville)
2. Iron Ore Company of Canada (Labrador City)
   Wabush Mines (Wabush Lake)
3. Wabush Mines, Pointe Noire (Pointe Noire)
4. Quebec Cartier Mining Company (Gagnon)
5. Hilton Mines, (Shawville)
6. Marmoraton Mining Company (Marmora)
8. National Steel Corporation of Canada, Limited (Capreol)
9. Sherman Mine (Temagami)
10. Adams Mine of Jones & Laughlin Mining Company, Ltd. (Kirkland Lake)
11. Algoma Ore Division of The Algoma Steel Corporation, Limited (Wawa)
12. Caland Ore Company Limited (Steep Rock Lake)
    Steep Rock Iron Mines Limited (Steep Rock Lake)
13. Griffith Mine, The (Bruce Lake)
15. Texada Mines Ltd. (Texada Is.)
16. Brynnor Mines Limited (Ucluelet)
17. Zeballos Iron Mines Limited (Zeballos)
18. Coast Copper Company, Limited (Benson Lake)
19. Jedway Iron Ore Limited (Moresby Is.)
    Wesfrob Mines Limited (Moresby Is.)

BYPRODUCT PRODUCERS

7. Falconbridge Nickel Mines, Limited (Falconbridge)
   The International Nickel Company of Canada, Limited (Copper Cliff)
14. Cominco Ltd. (Trail)

Company, Cleveland, Ohio. Dofasco owns 90 per cent and Tetapaga 10 per cent. The mine and pellet plant near Temagami were officially dedicated September 5 but the first shipment of pellets to Dofasco's Hamilton steel plant was made March 27. The plant, which cost $57 million and has an annual capacity to produce 1.1 million tons of pellets, is operated and managed by Cliffs of Canada Limited. Shipments in 1968, all to Dofasco's Hamilton, Ontario, plant, amounted to 762,014 tons.

TABLE 3

Consumption of Iron Ore in Canadian Iron and Steel Plants, by Type of Furnace, 1967-68
(tons)

	1967	1968
In blast furnaces direct	7,654,696	9,503,400
In steel furnaces direct	192,480	302,964
In sintering plants before ore is charged to blast or steel furnaces	948,053	913,795
Miscellaneous	444	172
Total	8.795,673	10,720,331

Source: American Iron Ore Association, compiled from company submissions.

BRITISH COLUMBIA

Brynnor Mines Limited, Kennedy Lake Division: Brynnor shipped 200,000 tons of concentrate from stocks on hand, to Japan in 1968. Mining operations were terminated in December 1967 and milling operations ceased in June 1968. Disposal of the plant and equipment was under way at the year's-end and approximately 34,000 tons of magnetite concentrate remained in stockpile. During the life of the operation, which began in 1962, some 3 million tons of concentrates were shipped to Japan.

TABLE 4

Consumption and Stocks of Iron Ore at Canadian Iron and Steel Plants, by Source, 1967-68
(tons)

	1967	1968
Receipts imported	2,442,405	2,596,747
Receipts from domestic sources	5,945,948	8,025,525
Total receipts at iron and steel plants	8,388,353	10,622,272
Consumption of iron ore	8,795,673	10,720,331
Stocks of ore at iron and steel plants, December 31	3,751,314	3,674,255
Change from previous year	-314,450	-77,059

Source: American Iron Ore Association, compiled from company submissions.

Coast Copper Company, Limited: Shipments from Coast Copper during 1968 amounted to 67,350 tons. Magnetite concentrates are recovered as a co-product with copper concentrates at the company's underground mine at Benson Lake, 26 miles southeast of Port McNeill on Vancouver Island. Crude ore grading 30.51 per cent Fe is beneficiated to produce a concentrate containing 64.93 per cent Fe.

Jedway Iron Ore Limited: Jedway ceased operations February 29, 1968 at its combined open-pit and underground mining operations on Moresby Island. Shipments from limited mining operations and from a stockpile, which was liquidated, amounted to 100,526 tons. Over the life of the operation, which began in 1962, the company shipped 2,038,688 tons of concentrate, all to Japan.

Texada Mines Limited: Texada shipped 528,895 tons of concentrate in 1968, all to Japan. The company operates an underground iron-copper mine on Texada Island. Production in 1968 amounted to 1,058,673 tons of crude ore grading 36.52 per cent Fe, from which 530,731 tons of concentrate were produced grading 61.6 per cent Fe.

Wesfrob Mines Limited: Wesfrob shipped 781,654 tons of concentrate grading 62.3 per cent Fe in 1968. The company operates an open-pit, iron-copper, operation on the west coast of Moresby Island. All shipments were to Japan. The company milled 1,653,455 tons of crude ore grading 35.25 per cent Fe and 0.38 per cent copper. Preparations for underground mining after the depletion of open-pit ore by or after 1975 are going ahead.

Zeballos Iron Mines Limited: Zeballos shipped 133,281 tons of concentrates grading 62.2 per cent Fe in 1968 from its underground mine near Zeballos. All shipments were to Japan.

TABLE 5

Production and Capacity of Pig Iron and Crude Steel at Canadian Iron and Steel Plants, 1967-68
(short tons)

	1967	1968p
Pig iron		
Production	6,940,374	8,382,601
Capacity at Dec. 31	9,276,000	9,580,000
Steel ingots and castings		
Production	9,694,371	11,250,996
Capacity at Dec. 31	12,894,075	13,114,375

Source: Dominion Bureau of Statistics.
p Preliminary.

WORLD PRODUCTION, MARKETS AND TRADE

World shipments of iron ore in 1968 amounted to an estimated 655 million tons, which is a large increase over shipments in 1967. World crude steel production on the other hand is estimated to have increased some 8 per cent to about 590 million short tons. Countries with significant growth in steel production included Japan where production rose from 68.6 million short tons in 1967 to 73.7 million short tons in 1968; the ECSC countries where production rose from 98.6 million short tons in 1967 to 110.4 million short tons in 1968; the USSR where production rose from 112.7 million short tons in 1967 to 120 million short tons in 1968; and the United States where production rose from 126.9 million short tons in 1967 to 130.7 million short tons in 1968. Increased crude steel production without a corresponding increase in iron ore shipments would indicate a combination of factors including an increase in the grade of iron ore shipped, a reduction of iron ore inventories and possibly an increase in the use of scrap metal.

Should the rate of growth of the world's steel industry continue without a corresponding development of iron ore resources the current iron ore surplus could be replaced by an iron ore shortage. In fact, there are those who believe that the current so-called over-supply of iron ore is more apparent than real; notwithstanding the downward pressure on prices being imposed on producers by consumers. At a rather modest rate of growth of 3¼ per cent a year, crude steel production by 1980 would exceed 900 million short tons and by the year 2000 would exceed 1,600 million short tons. Assuming that the grade of iron ore shipments does not change, this would require some 1,000 million tons of iron ore annually by 1980 and 1,800 million tons of iron ore annually by 2000.

Reported world pellet capacity at the end of 1968 was 95.78 million tons. This is an increase from 80.03 million tons in 1967 and an additional 19.5 million tons of pellet capacity is planned for installation before the end of 1970. Outside North America, this includes 2 million tons each for Brazil, Liberia and Japan; 2.5 million tons by the Netherlands; 4 million tons by the USSR, and 3.4 million tons by Sweden. Programs have also been announced for new plants and for expansion of existing facilities in Belgium, India, Italy, Mexico and Norway. In North America, only two projects, excluding plants designed to produce metallized or reduced iron ore, will be completed in this period. Inland Steel Company is building a pellet plant at Black River Falls, Wisconsin, to produce 0.75 million tons of pellets a year, beginning in 1968 and The International Nickel Company of Canada, Limited is increasing the annual capacity of its plant at Copper Cliff, Ontario, by 0.25 million tons, with completion scheduled for 1970.

Recent developments in the industry include a new pelletizing process in Sweden, production of self-fluxed pellets in Japan, large-scale pilot plant testing of carbonate-bonded pellets in the United States and the production of greatly reduced or metallized pellets.

Although many methods of producing reduced iron have proven technically feasible the economics were such that few methods have advanced beyond the pilot plant stage. However, with the development of improved reduction process, continuous charging techniques for high-power electric furnaces and the availability of low-cost electricity and low-cost natural gas, pre-reduced pellets have become not only technically possible but economically attractive for certain

TABLE 6

Canada, Iron Ore Producers, 1967 and 1968

Company and Property Location	Participating Companies	Material Mined and/or Treated (average natural grade)	Product Shipped (average natural grade)	Shipments[1] ('000 long tons) 1967	1968
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	Ore beneficiated by sink-float, sintered	1,572	1,778
Brynnor Mines Ltd.; near Ucluelet, Vancouver Island, B.C.[3]	Noranda Mines Ltd.	Magnetite from open-pit mine (54% Fe)	Magnetite concentrate (63% Fe)	123	200
Caland Ore Co. Ltd.; E. Arm of Steep Rock Lake, near Atikokan, Ont.	Inland Steel Co.	Hematite and goethite from open-pit mine	Pellets and concentrate	1,214C 971P	1,203C 1,039P
Carol Pellet Company; adjacent to IOC's concentrator, Labrador City, Labrador	U.S. participants of IOC	Company's plant operated by IOC, to process IOC concentrate	Pellets and concentrate	6,517P 1,357C	9,071P 875C
Coast Copper Co., Ltd.; Benson L., northern Vancouver Is., B.C.	Cominco Ltd.	Chalcopyrite and magnetite from underground mine	Magnetite concentrate	92	67
Griffith Mine, The; Bruce Lake, 35 miles south of Red Lake, Ont.	The Steel Co. of Canada, Ltd.; (Pickands Mather & Co. is the managing agent)	Magnetite from open-pit mine	Pellets	–	501
Hilton Mines; near Shawville, Que., 40 miles NW of Ottawa	The Steel Co. of Canada, Ltd.; Jones & Laughlin Steel Corp.; Pickands Mather & Co. (also managing agent)	Magnetite from open-pit mine	Pellets	911	636
Iron Ore Company of Canada (IOC); Schefferville, Que.	Labrador Mining and Exploration Co. Ltd.; Hollinger Mines Limited; The Hanna Mining Co.; Armco Steel Corp.; Bethlehem Steel Corp.; National Steel Corp.; Republic Steel Corp.; Wheeling Steel Corp.; The Youngstown Sheet and Tube Co. (Hollinger-Hanna Ltd., equally owned by Hollinger Mines and Hanna Mining, manages IOC)	Hematite-goethite-limonite from open-pit mines	Direct-shipping ore	6,516	6,514

TABLE 6 (Cont'd)

Company and Property Location	Participating Companies	Material Mined and/or Treated (average natural grade)	Product Shipped (average natural grade)	Shipments[1] ('000 long tons) 1967	1968
Jedway Iron Ore Ltd.; Moresby Island, Queen Charlotte Is., B.C.[3]	The Granby Mining Co., Ltd.	Magnetite from open-pit mines (36.6% Fe estimated)	Magnetite concentrate (60.3% Fe)	374	101
Jones & Laughlin Mining Co., Ltd. (Adams Mine); Boston Twp., near Kirkland Lake, Ont.	Jones & Laughlin Steel Corp.	Magnetite from open-pit mine	Pellets	1,086	1,104
Marmoraton Mining Co., Division of Bethlehem Chile Iron Mines Company; near Marmora, Ont.	Bethlehem Steel Corp.	Magnetite from open-pit mine	Pellets	453	454
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	Pellets	646	680
Quebec Cartier Mining Co.; Gagnon, Quebec	United States Steel Corp.	Specular hematite from open-pit mine	Specular hematite concentrate	8,245	8,601
Sherman Mine; near Timagami, Ont.	Dominion Foundries and Steel, Limited, 90%; The Cleveland-Cliffs Iron Company (also managing agent) 10%	Magnetite from open-pit mines (22-25% Fe)	Pellets	–	762
Steep Rock Iron Mines Ltd.; Steep Rock Lake, N. of Atikokan, Ont.	Publicly-owned company	Hematite-goethite from open-pit mine	Direct shipping ore and pellets	890C 275P	242C 1,058P
Texada Mines Ltd.; Texada Island, B.C.	Kaiser Aluminum & Chemical Corp.	Magnetite and chalcopyrite from underground mines; some from open-pit mine	Magnetite concentrate	680	529
Wabush Mines; Scully Mine Division includes Scully Mine and concentrator at Wabush, Labrador; Pointe Noire Division includes pelletizing plant at Pointe Noire, Quebec	The Steel Co. of Canada, Ltd.; Dominion Foundries and Steel, Ltd.; The Youngstown Sheet and Tube Co.; Inland Steel Co.; Interlake Steel Corp.; Pittsburgh Steel Co.; Finsider of Italy and Pickands Mather & Co., (also managing agent)	Specular hematite and some magnetite from open-pit mine	Pellets	4,974	5,483

TABLE 6 (Cont'd)

Company and Property Location	Participating Companies	Material Mined and/or Treated (average natural grade)	Product Shipped (average natural grade)	Shipments[1] ('000 long tons) 1967	1968
Wesfrob Mines Limited; Tasu Harbour, Moresby Is., Queen Charlotte Is., B.C.	Falconbridge Nickel Mines, Limited	Magnetite and chalcopyrite from open-pit mines	Magnetite pellet-feed and sinter-feed concentrate	208	741
Zeballos Iron Mines Ltd.; near Zeballos, Vancouver Is., B.C.	Falconbridge Nickel Mines, Limited	Magnetite from underground mine	Magnetite concentrate	219	133
BYPRODUCT PRODUCERS					
Cominco Ltd.; Kimberley, B.C.	Publicly-owned company	Pyrrhotite flotation concentrates roasted for acid production. Calcine sintered	Iron oxide sinter is processed into pig iron at plant	151	132
Falconbridge Nickel Mines, Ltd.; Falconbridge, Ont.	Publicly-owned company	Pyrrhotite flotation concentrates treated	Calcine	65	67
The International Nickel Co. of Canada, Ltd.; Copper Cliff, Ont.	Publicly-owned company	Pyrrhotite flotation concentrates treated	Pellets	708	654
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 (40% Fe, 35% TiO_2) from open-pit mine at Lac Tio, beneficiated and calcined at Sorel	Ore smelted by electric smelting to TiO_2 slag, and various grades of desulphurized pig iron or remelt iron	1,092[2]	1,232[2]

Sources: Company reports and personal communication.

[1]Statistics supplied by companies to Mineral Resources Branch. [2]Ore smelted. [3]No longer operating.
– Nil; [C]Concentrate; [P]Pellets; [D]Direct shipping ore.

TABLE 7

World Iron Ore Pellet Capacity, 1968 and Estimated Capacity in 1970
(million long tons)

Year	Canada	USA	Balance of World	Total
1968	24.83	50.30	20.65	95.78
1970	25.08	51.05	39.13	115.26

Source: Compiled by Mineral Resources Branch from information derived from correspondence, American Iron Ore Association, Wambesco and Trade Publications.

applications. In all, some 12 companies in 10 countries have announced plans to build 18 plants to produce some 3.5 million tons reduced iron ore. Except for Orinoco Mining Company which will produce reduced iron ore in the form of briquettes for blast furnace feed, all the other reduced iron production under consideration will be for either electric arc steelmaking or pig iron smelting furnaces. In addition to these proposed plants, Hamersley Iron Proprietary Ltd. has carried out extensive studies on the production of a "metallized agglomerate", having an iron content of above 90 per cent, which it calls HImet. If Hamersley goes ahead with the project, the proposed plant capacity will be 1.2 million tons of HImet a year.

Three metallizing plants are now under construction in North America. At Falconbridge, Ontario, Falconbridge Nickel Mines, Limited, will use the Stelco-Lurgi/RN process to produce reduced iron ore pellets from a pyrrhotite calcine at the rate of 300,000 tons annually beginning in 1969. They will contain about 90 per cent iron and 1.5 per cent nickel. This product will be charged directly into steelmaking furnaces.

At Mobile, Alabama, the McWane Cast Iron Pipe Co. will use a travelling grate to produce a 75 per cent metallized pellet from West African ore. This product will be delivered to an electric smelting furnace for production of 200,000 tons of pig iron annually, beginning in 1969. Midland-Ross Corporation will produce at its Portland, Oregon, plant 300,000 tons of reduced pellets containing 95 per cent iron annually, beginning in 1969. Midland-Ross will build and operate the pellet plant and Oregon Steel Mills, a division of The Gilmore Steel Corp., will use the

TABLE 8

Canada, Iron Ore Pellet Plants Operating Year-End 1968

Operating Company	Location	Type of Plant*	Annual Capacity (million long tons)	Starting Date
CANADA				
Bethlehem Steel Corp.				
Marmoraton Mining Co.,	Ontario (Marmora)	S	0.50	1955
Cleveland-Cliffs Iron, Co., The				
Sherman Mine (Dofasco)	Ontario (Timagami)	G-K	1.00	1968
Hanna Mining Company, The				
Carol Pellet Co., (IOC)	Nfld. (Labrador City)	CG	10.00	1963
National Steel Corporation				
of Canada, Limited	Ontario (Moose Mtn.)	S	0.63	1963
Inland Steel Company				
Caland Ore Company Limited	Ontario (Steep Rock Lake)	CG	1.00	1965
International Nickel Co., of				
Canada, Limited. The	Ontario (Copper Cliff)	CG	0.85	1956
Jones & Laughlin Steel Corp.				
Adams Mine	Ontario (Kirkland Lake)	G-K	1.10	1964
Pickands Mather & Co.,				
Griffith Mine, The (Stelco)	Ontario (Bruce Lake)	S	1.50	1968
Hilton Mines	Quebec (Shawville)	S	0.90	1958
Wabush Mines, Pointe Noire	Quebec (Pointe Noire)	CG	6.00	1965
Steep Rock Iron Mines Limited	Ontario (Steep Rock Lake)	CG	1.35	1967
Total, Canada (1968)			24.83	

*Includes shaft (S); continuous grate (CG) and grate-kiln (G-K).

TABLE 9

World Production of Iron Ore, by Country, 1965-68
(thousands long tons)

	1965	1966	1967	1968P
USSR	150,458	157,474	165,346	174,000
United States	87,842	90,147	84,195	83,441
France	58,585	54,181	49,058	54,894
Canada	35,678	36,331	37,784	44,083
China	38,400	39,400	31,494	31,500
Sweden	29,019	27,761	28,292	32,282
India	16,634	25,920	25,392	27,200
Brazil	17,220	20,700	24,900	24,000
Australia	6,695	11,553	18,740	20,000
Liberia	15,707	16,593	18,700	17,900
Venezuela	17,125	17,479	16,850	15,537
Britain	15,413	12,457	12,647	13,000
Chile	11,229	12,053	11,397	11,000
West Germany	10,676	9,318	8,416	7,591
Other countries	95,640	88,702	85,934	. .
World Total	606,330	620,069	619,145	655,000e

Sources: Dominion Bureau of Statistics; American Iron and Steel Institute Report, 1967, United States Bureau of Mines, Commodity Data Summaries, January 1969; and Correspondence.
P Preliminary; e Estimated; . . Not available.

output in a new, integrated electric furnace steel mill that it will build adjacent to the pellet plant. High-quality iron ore is to be delivered to the Oregon plant from Peru by Marcona Mining Company in slurry form. The iron ore is first converted to oxidized pellets then reduced to metallic iron by reduction gases.

Midland-Ross also announced in early 1969 that it will construct jointly with Korp Industrie Und Handel Gmbh & Co., two similar plants in Europe. One will be at Hamburg, West Germany, and another will be at an unspecified location in the Netherlands.

From a small exporter in 1950, Canada became the world's leading exporter of iron ore in 1963, a position maintained through 1968. Canada is by far the largest supplier to the United States followed by Venezuela, Liberia and Brazil. It is the second largest supplier to Britain after Sweden; Britain consumes increasing tonnages of pellets each year, most of which come from Canada.

After the United States, Japan is the world's second largest iron ore importer and its sources are many. Japanese ore requirements have increased rapidly in recent years and new sources are continually being sought. Australia became Japan's major supplier in 1967. Other major suppliers are India (including Goa), Malaysia, Chile and Peru. In 1968, Australia exported an estimated 13.8 million tons of iron ore to Japan. According to the Bureau of Mineral Resources, Geology and Geophysics, Department of National Development, Australia, the various companies with projects under way have export contracts amounting to some 455 million tons to be fulfilled during the next 25 years. Some contracts are of long duration and others are as short as 3 years but average exports from 1970, based on existing contracts, will exceed 28 million tons a year. Other contracts in the process of negotiation could increase Australia's total iron ore

TABLE 10

Lake Superior Ore Prices*

	$ U.S.
Mesabi Non-Bessemer	10.55
Coarse	11.35
Fine	10.10
Mesabi Bessemer (+ phos. premium)	10.70
Old Range Bessemer	10.95
High Phosphorus	10.55
Old Range Non-Bessemer	10.80
Open Hearth Lump, Marquette	12.60
Pellets (per iron nat. unit)	0.252

Source: Skillings' Mining Review, November 23, 1968.
*Per gross ton, 51.50% of iron natural, at rail of vessel lower lake port.

and pellet shipments to Japan and other countries to more than 40 million tons annually and Australia would then probably replace Canada as the world's leading exporter of iron ore.

PRICES AND TARIFFS

Prices received by most iron ore producers in central and eastern Canada for sale to North American consumers reflect the Lake Erie base price, which is the price paid for a long ton unit of iron*, in iron ore delivered to rail of vessel at Lake Erie ports. The Canadian mine price can be approximated by deducting the appropriate handling and transportation charges. The Lake Erie price is based on a natural iron content of 51.5 per cent and various other physical and chemical specifications.

The Lake Erie price rose steadily from the mid-1940's until April 1962 when it declined 7 per cent as a result of increasing supplies in a weak market and falling prices in international markets. Great Lakes freight rates were reduced 10 cents a ton in mid-1963, thereby lowering the Lake Erie base price by that amount at which level it has remained.

Prices received by British Columbia mines on ore sales to Japan are negotiated between producers and consumers but are generally about 15 cents a dry metric ton unit (22.04 lb of iron) f.o.b. shipping port, based on ore grading 58 to 62 per cent iron. Recently-negotiated contracts call for somewhat lower prices because of more severe marketing conditions in Japan that have been caused by greater availability of supplies from Australia and more substantial sources of supply each year.

Quoted prices paid by Japanese steel producers are shown in the accompanying list.

There has been accelerated investment in pelletizing plants but pellet list prices have held firm. Lake Superior pellets grading 62 to 63 per cent iron are quoted at 25.2 cents a long ton unit (U.S. $15.62 to $15.88 a ton) delivered to rail of vessel at lower lake ports. There has been no price change for pellets for several years. Recent reports indicate that the Japanese have negotiated contracts in Australia for pellets at 22.4¢ a long ton unit, c.i.f. Japan.

Neither Canada nor any of its iron ore customers have tariffs on iron ore.

Sources of Information	% Fe	Source of Ore	Cost in U.S. ¢/Unit
Metals Week 11/3/68	68(d)	Brazil (VRD) (1)	22.6(a)
" " "	" (d)	" (1)	20.2(a)
" " "	" (d)	" (2)	19.6(a)
Japan Metal Daily 8/3/68	" (d)	Sierra Leone	16 (a)
" " " 10/2/68	65(p)	India	15.4(b)
" " " "	66	"	15.9(b)
Metals Week 25/12/68	63.5(p)	Australia (Robe River)	18.75(b)
" " "	56(f)	" "	10.75(b)
Japan Metal Daily 5/12/67	63(d)	Australia (Mt. Newman)	14.8(b)
" " " "	61(f)	" "	12.3(b)
Metals Week 11/9/67	57(b)	China	15.6(b)

(a) – c.i.f. Japan; (b) f.o.b.; (1) 90,000-ton vessels; (2) 125,000-ton vessels; (p) pellets; (f) fines; (d) direct-shipping.

*Equals 22.4 pounds of iron(i.e. 1% of 2,240 pounds). An iron ore containing 60 per cent Fe, therefore, has 60 units.

Iron and Steel

G.E. WITTUR*

The Canadian primary iron and steel industry experienced a significant improvement in 1968 as a whole. Crude steel production (ingots and castings) reached a record 11.25 million tons**, a 16 per cent increase from the 9.7 million tons made in 1967. Several factors contributed to the rise but the most important were a substantial increase in exports, reduced imports and a significant rise in demand from the automobile, pipe and construction industries. Primary steel, pipe and wire exports exceeded imports in terms of both tonnage and value for the first time in 1969. Indicated consumption was 11.1 million tons compared with 10.3 million tons in 1967 and 10.8 million tons in 1966.

There was a significant decline in capital investment by iron and steel mills, to $85.8 million compared with $122.9 million in 1967. Capital expenditures are expected to rise to about $150 million in 1969. Major investment programs announced recently by the larger steel companies indicate that capital expenditures are likely to remain at high levels for several years.

The outlook for iron and steel for 1969 is for somewhat reduced exports but a moderate increase in domestic demand. Production rates are expected to continue at high levels until at least mid-year. Labour contracts at three of the four largest plants expire in 1969 (one in April, two in July) and the threat of strikes is likely to prompt some defensive inventory build-up on the part of consumers. Demand may thus ease slightly in the second half of the year. Imports are not expected to rise more than moderately unless lengthy production stoppages occur due to strikes. Production for the year, also partly dependent upon possible work stoppages, should at least reach and may exceed that in 1968.

WORLD PRODUCTION

Canada retained twelfth place among world steel producers in 1968, with two per cent of world output. According to preliminary figures, world steel production rose 7.7 per cent to 588 million tons in 1968. Production rose in most countries, with a significant recovery in some of the traditional producing countries in Europe. Among the leading producers, output rose 9.7 per cent in the six-nation European Coal and Steel Community, 8.2 per cent in Britain, 7.6 per cent in Japan, 3.9 per cent in the USSR and 3.1 per cent in the United States. Inventory building in the United States, due to a strike threat, was an important growth factor for both Japanese and western European steel production although home demand continued to be strong in the former and recovered in the latter.

*Mineral Resources Branch.
**The net ton of 2,000 pounds is used throughout.

TABLE 1

Canada – General Statistics
of the Domestic Primary Iron and Steel Industry, 1966-68

	1966[r]	1967[r]	1968[p]
Production			
Volume Indexes (1961 = 100)			
Total Industrial Production	148.9	151.7	159.2
Iron and Steel Mills	153.2	148.1	169.7
Value of shipments* ($ millions)	1,256.8	1,211.0	1,334.5
Value of unfilled orders, year-end* ($ millions)	147.8	158.0	157.3
Value of inventory owned, year-end* ($ millions)	267.8	262.2	273.3
Employment			
Administrative	8,015	8,125	. .
Hourly rated	37,984	36,078	. .
Total	45,999	44,203	45,043
Employment index, all employees (1961 = 100)	133.8	129.2	130.6
Average hours per week, hourly-rated	40.3	40.0	40.2
Average earnings per week, hourly-rated (dollars)	118.21	124.39	132.86
Average wages and salaries per week, all employees (dollars)	123.57	130.71	138.92
Expenditures ($000)			
Capital: on construction	35,100	19,128	13,273
on machinery	175,460	103,740	72,536
Total	210,560	122,868	85,809
Repair: on construction	7,135	7,225	7,335
on machinery	138,004	132,764	144,818
Total	145,139	139,989	152,153
Total Capital and Repair	355,699	262,857	237,962
Trade – Primary Iron and Steel**			
Exports ($ millions)	214.7	223.2	310.9
Imports ($ millions)	308.4	310.7	284.9

Source: Dominion Bureau of Statistics.

*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. **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.

[r] Revised; [p] Preliminary; . . Not available.

CANADIAN PRIMARY IRON AND STEEL INDUSTRY†

Pig iron is made at seven plants in Canada, while steel ingots are made at 18 plants; five of these produce both iron and steel. There are also three plants that have rolling mills but no iron or steel furnaces. The four largest integrated plants–two at Hamilton, Ontario and one each at Sault Ste. Marie, Ontario and Sydney, Nova Scotia–accounted for 92 per cent of 1968 pig iron production and 86 per cent of crude steel production.

†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". A more comprehensive description of the industry, with extensive supporting statistics, is contained in MR 92, Primary Iron and Steel in Canada (116 pages), by G.E. Wittur. Both are available from the Mineral Resources Branch or the Queen's Printer.

PIG IRON

Production of pig iron rose 20.8 per cent in 1968, to a record 8,382,601 tons (Table 3). Capacity had risen sharply in 1967 upon completion of a large new blast furnace and an electric furnace. Most pig iron is further processed into steel at the same plants;

shipments to other consumers rose 21.3 per cent, however. Exports and imports both rose in 1969. Construction of a new blast furnace is under way at Dominion Foundries and Steel, Limited, and another is planned by The Algoma Steel Corporation, Limited.

CRUDE STEEL

Production of crude steel rose 16 per cent in 1968 (Table 4). Ingot and continuous-cast steel production rose 16.3 per cent to 11,108,607 tons while steel castings production declined by less than one per cent to 142,389 tons. Open hearth furnaces produced 55.1 per cent of total crude steel, up from 53.9 per cent in 1967, while basic oxygen furnaces accounted for 31.1 per cent, down from 33.2 per cent the previous year. This is the reverse of trends in most major steel-producing countries where oxygen-furnace production is increasing rapidly but investment projects under way or planned at Canadian steel plants will result in basic oxygen-furnaces accounting for more than half of total capacity within three to five years. Electric furnaces produced 13.8 per cent of the total in 1968, compared with 12.9 per cent in 1967.

TABLE 2

World Production of Steel, 1966-68
(thousands of net tons)

	1966	1967P	1968P
North America, total	144,104	136,907	142,349
Canada	10,003	9,694	11,251
United States	134,101	127,213	131,098
Latin America, total	10,173	10,719	12,148
Western Europe, total	139,637	145,238	159,147
Belgium	9,828	10,706	12,751
France	21,589	21,666	22,498
West Germany	38,929	40,504	45,370
Italy	15,034	17,518	18,699
Luxembourg	4,839	4,939	5,329
Netherlands	3,600	3,752	4,090
Total ECSC	93,819	99,085	108,737
Britain	27,233	26,763	28,960
Other	18,585	19,390	21,450
Eastern Europe, total	140,564	148,449	155,900
Czechoslovakia	10,068	10,899	11,600
Poland	10,860	11,450	12,100
USSR	106,890	112,655	117,100
Other	12,746	13,445	15,100
Africa, total	3,941	4,370	4,700
Middle East, total	392	400	400
Far East, total	73,615	92,408	105,835
China	11,550	14,000	15,000
India	7,283	7,400	7,400
Japan	52,672	68,521	73,735
Other	2,110	2,487	9,700
Oceania, total	6,698	7,116	7,400
Australia	6,553	6,946	7,180
Other	145	170	220
World total	519,124	545,607	587,879

Sources: 1966-67 – Annual Statistical Report, American Iron and Steel Institute; 1968 – OECD, ECE and ECSC reports, Metal Bulletin and others.

P Preliminary.

Total crude steel capacity was 13.1 million tons at the end of 1968, only a slight increase from that of 1967. A number of plants will be expanded in the next few years and annual capacity is expected to rise to more than 16 million tons by 1973.

SHIPMENTS OF STEEL PRODUCTS

Almost all types of steel products made in Canada were in reasonable supply in 1968, although mill delivery schedules for many products lengthened significantly compared with 1967, especially during the first half of the year but also in the fourth quarter. Shipments of hot- and cold-rolled steel products rose 17.7 per cent to 8,211,358 tons (Table 6). Shipments from iron and steel mills were valued at $1,334.5 million (Table 1), up 10.2 per cent.

Shipments of rolled steel by product (Table 6) show that increased deliveries were led by reinforcing bars (up 30.6 per cent), hot-rolled sheet and strip (24.5 per cent), wire rod (24.5 per cent), heavy structurals (22.8 per cent) and plate (including heavy skelp) (18.7 per cent). Inter-plant movement of semis (slabs and billets) rose substantially. Shipments of most other products also rose although rails were down 17.2 per cent and track material and cold-finished bars were off slightly.

Shipments of rolled products by industry (Table 7) showed large increases to the pipe and tube industry (up 36.6 per cent), the construction industry (20.7 per cent), the automobile and aircraft sector (18.4 per cent) and the wire and wire products industry (15.4 per cent). These four are the largest steel consumers in Canada, accounting for more than half of domestic steel purchases, and trends in their growth are of vital importance to the steel industry. The pipe and tube industry tends to be highly cyclical. The increase in production in 1968 resulted from large-scale installation of petroleum and natural gas lines in Canada coupled with the first major-tonnage export of line pipe. Although some reduction in pipe production is expected in 1969, output should nevertheless be higher than the average of the past few years. The strong recovery in construction in 1968 is expected to

TABLE 3

Canada, Pig Iron Production, Shipments, Trade and Consumption, 1966-68
(net tons)

	1966ʳ	1967	1968ᵖ
Furnace capacity, December 31	7,764,000	9,276,000	9,580,000
Production			
Basic iron	6,366,232	6,170,176	7,561,936
Foundry iron	503,019	532,159	560,499
Malleable iron	347,359	238,039	260,166
Total	7,216,610	6,940,374	8,382,601
Shipments			
Basic iron	59,112	43,749	118,330
Foundry iron	432,306	472,341	576,042
Malleable iron	254,617	234,943	216,759
Total	746,035	751,033	911,131
Imports - net tons	32,456	28,743	36,777
- value ($000)	1,451	1,295	1,812
Exports - net tons	507,239	485,695	548,643
- value ($000)	27,056	25,382	26,967
Consumption of pig iron			
Steel furnaces	6,289,196	6,094,969	7,379,905
Iron foundries	303,114	281,080	315,658
Consumption of iron and steel scrap			
Steel furnaces	5,013,356	4,968,422	5,372,201
Iron foundries	1,056,885	970,381	978,797

Source: Dominion Bureau of Statistics, Primary Iron and Steel (monthly) and Iron and Steel Mills (annual).
ʳ Revised; ᵖ Preliminary.

continue into 1969 and steel consumption should rise again. Canadian steel consumption in the automotive industry has grown rapidly since introduction of the Canada-United States automotive agreement in 1964. However, an easing in the rate of growth in steel consumption may occur in 1969. Prospects in the wire, wire products and fasteners group are for moderate growth in 1969.

Nearly all other industries purchased more domestic steel in 1968 except for agricultural equipment manufacturers, reflecting work stoppages through strikes and reduced equipment sales to prairie grain farms, railway rolling stockmakers, and shipbuilders. Moderate growth is expected in most consuming industries in 1969. Rising new home starts should result in strong demand for appliances. An improvement in railway equipment production is expected in 1969 but prospects for agricultural equipment are not favourable in the short term. Shipbuilding has declined for several years and no improvement is in sight.

TABLE 4

Canada, Crude Steel Production, Shipments, Trade and Consumption, 1966-68
(net tons)

	1966r	1967	1968p
Furnace capacity, December 31			
Steel ingot			
Basic open-hearth	6,470,000	6,970,000	6,970,000
Basic oxygen converter	3,630,000	3,630,000	3,800,000
Electric	1,680,410	1,793,650	1,923,650
Total	11,780,410	12,393,650	12,693,650
Steel castings	404,000	500,425	420,725
Total	12,184,410	12,894,075	13,114,375
Production			
Steel ingot			
Basic open-hearth	5,284,345	5,225,967	6,189,450
Basic oxygene	3,377,733	3,208,655	3,509,038
Electric	1,158,927	1,116,552	1,410,119
Total	9,821,005	9,551,174	11,108,607
of which continuously cast	442,680	647,252	947,095
Steel castings			
Basic open-hearth	2,541	*	*
Electric	196,585	143,197	142,389
Total	199,126	143,197	142,389
Total Steel Production	10,020,131	9,694,371	11,250,996
Alloy Steel in Total	834,413	746,188	804,659
Shipments from Plant			
Steel ingots	304,820	296,136	393,339
Steel castings	173,050	141,561	138,187
Rolled steel products	7,291,440	6,980,421	8,211,358
Total	7,769,310	7,418,118	8,742,884
Exports in equivalent steel ingots	1,289,809	1,367,702	2,078,962
Imports in equivalent steel ingots	2,096,457	1,981,073	1,884,983
Indicated Consumption**	10,826,779	10,307,742	11,057,017

Source: Dominion Bureau of Statistics; estimates by Department of Energy, Mines and Resources, Ottawa.
*Included with electric.
**Crude steel production plus imports less exports.
r Revised; p Preliminary; e Estimated.

TABLE 5

Canada, Production, Trade and Apparent Consumption of Primary Iron and Steel, 1959-68

(000 net tons equivalent ingot)

	Crude Steel Production	Imports*	Exports*	Indicated** Consumption
1959	5,901	1,506	602	6,805
1960	5,809	1,353	994	6,168
1961	6,488	1,096	841	6,743
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[r]	10,020	2,096	1,290	10,826
1967[r]	9,694	1,981	1,368	10,307
1968[p]	11,251	1,885	2,079	11,057

Source: Dominion Bureau of Statistics.
*From Trade of Canada adjusted to equivalent crude steel by Mineral Resources Branch. **Production plus imports, less exports with no account taken of stocks.
[r]Revised; [p]Preliminary.

TABLE 6

Canada, Shipments of Rolled Steel Products by Type, 1966-68

(net tons)

	1966	1967	1968[p]
Hot-rolled products			
Semis	326,262	343,908	544,023
Rails	282,293	279,076	231,178
Wire rods	428,109	424,793	529,252
Structurals			
Heavy	433,159	373,908	459,285
Light	86,787	123,856	126,838
Bars, concrete reinforcing	655,525	495,202	646,787
Bars, other hot-rolled	686,120	694,850	754,358
Tie plate and track material	62,872	56,526	54,931
Sheet and strip	1,210,119	1,289,444	1,605,365
Plates	935,687	915,842	1,086,996
Total	5,106,933	4,997,405	6,039,013
Cold-rolled products			
Bars	78,987	74,801	71,962
Sheet, tin mill black-plate and tinplate	1,401,589	1,372,051	1,510,704
Galvanized sheet	540,881	536,164	589,679
Total	2,021,457	1,983,016	2,172,345
Total shipments	7,128,390	6,980,421	8,211,358
Alloy steel in shipments	366,348	395,205	459,374

Source: Dominion Bureau of Statistics, Primary Iron and Steel (monthly).
[p]Preliminary.

TABLE 7

Canada, Rolled Steel Products, Shipments to Consuming Industries, 1966-68
(net tons)

	1966	1967	1968P
Automotive and aircraft	642,939	697,591	826,077
Agricultural equipment manufacturers	214,925	191,312	156,612
Construction	1,406,735	1,194,946	1,442,361
Containers	462,279	461,942	483,588
Machinery and tools	300,567	261,606	269,586
Wire, wire products and fasteners	513,349	520,019	598,735
Resources and extraction	176,643	180,832	198,258
Appliances, utensils, stamping, pressing	544,106	518,659	544,099
Railway operating	258,939	240,300	255,737
Railway cars and locomotives	127,182	85,787	58,866
Shipbuilding	101,240	59,655	45,486
Pipes and tubes	762,652	823,079	1,123,585
Wholesalers and warehouses	924,364	811,175	969,003
Miscellaneous	19,771	28,149	81,892
Total	6,455,691	6,075,052	7,053,885
Direct Exports*	672,699	905,369	1,157,473
Total	7,128,390	6,980,421	8,211,358

Source: Dominion Bureau of Statistics, Primary Iron and Steel (monthly).
*Does not include exports by nonproducers, nor ingots and castings.
P Preliminary.

TRADE

Canada's balance of trade in primary steel products plus castings, forgings, pipe and wire continued to improve in 1968, with a sharp rise in exports and a moderate reduction in imports. Omitting pig iron, where exports exceed imports by a large margin, Canada's balance of trade was positive in terms of both tonnage and value for the first time, although value of rolled steel imports still exceeded that of exports (Tables 8 and 9).

In terms of tonnage, exports rose 52.4 per cent and imports fell 6.7 per cent. In terms of value, exports rose by 43.6 per cent but exceeded imports, whose value fell by 8.5 per cent, by less than one million dollars. Among individual products exported, only castings, ingots, rails and track material and certain types of coated sheet and strip registered declines. Large increases occurred in semis, plate, hot- and cold-rolled sheet and strip, and pipe. Among imports, only wire rod, hot- and cold-rolled sheet and strip and wire rose.

Trends in Canada's trade in primary steel in 1968 were in large measure related to hedge-buying in the United States that occurred prior to the successful negotiation at mid-year of a new three-year labour contract covering the major part of the steel industry in that country. The United States is the most significant individual supplier of Canadian steel imports (27.5 per cent of the total in 1968) and market for exports (77.9 per cent) (Table 10). The six ECSC countries as a bloc supplied 33.4 per cent of imports, Japan supplied 15.4 per cent and Britain accounted for 12.7 per cent. Imports from Eastern Europe are rising in importance, however. Latin America is Canada's second most important steel market after the United States, followed by Britain.

Trade prospects for 1969 are for lower exports to the United States and, although sales to many other countries may strengthen, total exports may thus decline. Imports may rise moderately, barring lengthy strikes at Canadian steel plants in 1969, but a general, almost world-wide, upsurge in steel demand has led to a rather remarkable increase in international steel prices.

MANPOWER AND LABOUR

The index of employment in the primary iron and steel industry (1961 = 100) rose from 129.2 in 1967 to 130.6 in 1968; total employment rose 1.9 per cent to 45,043 (Table 1). Average weekly hours worked in 1968 were 40.2, and earnings by hourly-rated employees averaged $132.86, up 6.8 per cent from 1967. The labour situation was more peaceful in 1968 than in 1967, both in the steel industry itself and in major steel-consuming sectors. The few work stoppages in the steel industry were mainly shortlived. The strike of St. Lawrence Seaway workers at mid-year did not directly affect the steel industry seriously.

RAW MATERIALS

Consumption of nearly all raw materials rose significantly at Canadian iron and steel plants in 1968 but there were few serious supply problems. The tonnage of iron ore, including plant sinter, charged to iron and steel furnaces at the six main consuming plants rose 22 per cent to 12.8 million net tons. In addition, 1.4 million tons of ilmenite were smelted to produce pig iron and titania slag (Table 12). Iron ore mined and processed in Canada accounted for nearly four fifths of domestic consumption, compared with three quarters in 1967 and 54 per cent in 1966. Pelletized ore accounted for 66 per cent of all iron ore used in iron furnaces compared with 58 per cent in 1967 and 52 per cent in 1966. Sinter accounted for a further 27 per cent.

Consumption of scrap in steel furnaces at all plants in Canada rose only 8 per cent in 1968 while use of pig iron rose 21 per cent (Table 3). Scrap was in adequate supply in the major steel-producing centres and prices remained at low levels, but some regional steel producers, notably in western Canada, continued to have difficulty in obtaining supplies of desirable grades and prices were much firmer than in Ontario.

The potential of reduced iron ore pellets as a primary steel furnace charge in place of scrap continued to attract growing interest. Falconbridge Nickel Mines, Limited is building a 300,000-annual-ton plant near Sudbury, Ontario to produce reduced iron pellets containing 1.5 per cent nickel but other than this

TABLE 8

Canada, Trade in Steel Castings, Ingots and Rolled Products, 1966-68
(000 net tons)

	Imports			Exports		
	1966	1967	1968p	1966	1967	1968p
Steel castings	9.0	9.0	6.1	20.8	25.6	23.5
Steel forgings	9.9	11.9	11.9	22.9	25.4	28.6
Steel ingots	16.1	3.1	1.0	133.7	121.5	84.1
Hot-rolled products						
Semis	21.7	29.6	8.8	87.3	54.3	214.1
Rails	6.1	4.0	6.0	77.4	90.4	64.0
Wire rod	144.0	130.6	152.6	8.0	16.7	48.3
Structurals	369.1	351.8	319.4	37.2	56.7	77.5
Bars	244.5	207.9	172.8	49.0	50.2	69.5
Track material	3.5	1.9	1.7	13.9	6.0	3.2
Plates	221.2	210.1	190.8	40.3	47.3	101.6
Sheet and strip	80.3	82.1	95.4	131.6	154.9	238.1
Total, hot-rolled	1,090.4	1,018.0	947.5	444.7	476.5	816.3
Cold-rolled and other products						
Bars	11.3	11.8	11.0	8.9	6.9	11.6
Sheet and strip						
Cold-rolled	24.6	22.3	25.5	115.2	113.8	161.2
Galvanized	7.3	7.4	7.3	57.2	88.4	88.0
Other*	112.3	110.8	110.8	125.3r	134.8r	124.9
Pipe	197.6	220.0	188.9	92.1r	75.3r	283.3
Wire	74.9	62.9	67.6	7.0	7.9	18.2
Total, cold-rolled	428.0	435.2	411.1	405.7	427.1	687.1
Total, rolled products	1,518.4	1,453.2	1,358.6	850.4	903.6	1,503.4
Total, steel	1,553.4	1,477.2	1,377.6	1,027.8	1,076.1	1,639.6

Source: Dominion Bureau of Statistics, Trade of Canada, Compilation by Mineral Resources Branch.
*Includes hot-rolled stainless sheet and strip.
p Preliminary; r Revised.

special situation, no definite plans to proceed with commercial production of reduced iron pellets in Canada were announced. A few plants are operating or under construction in other countries and some industry executives have predicted that use of reduced ore will be one of the major technological stages in the next decade.

New coke batteries completed in 1967 assure adequate coke supplies for several years. The coking facilities at Sydney Steel Corporation were sold in 1968 (effective May 1) to Cape Breton Development Corporation (DEVCO), who hopes to increase coke sales to take advantage of unused capacity. The Algoma Steel Corporation, Limited completed development of a new coal-mine in West Virginia. Development of large coal-mines in the Canadian Rockies to supply coking coal to Japan has resulted in investigations by some domestic steel companies to determine the feasibility of obtaining coal from this area.

TABLE 9

Canada, Value of Trade in Steel Castings, Ingots and Rolled Products, 1966-68
($000)

	Imports			Exports		
	1966	1967	1968p	1966	1967	1968p
Steel castings	6,783	6,800	5,120	7,450	7,679	8,037
Steel forgings	10,911	13,652	14,671	11,803	12,626	14,772
Steel ingots	1,320	1,065	241	13,691	14,220	6,870
Rolled products						
Hot-rolled	138,547	133,069	123,216	69,850	71,042	107,786
Cold-rolled and other	149,417	154,808	139,824	84,871	92,238	146,517
Total	287,964	287,877	263,040	154,721	163,280	254,303
Total, steel	306,978	309,394	283,072	187,665	197,805	283,982

Source: Dominion Bureau of Statistics, Trade of Canada.
Note: The values in this table relate to the tonnages shown in Table 8.
pPreliminary.

TABLE 10

Canada, Trade in Steel by Country, 1966-68
(thousand net tons)

	Imports From:			Exports To:		
	1966	1967	1968p	1966	1967	1968p
United States	467.3	400.2	379.4	732.9	668.3	1,273.7
Britain	127.9	169.7	175.4	22.1	115.1	93.1
ECSC† Countries	560.1	518.6	459.4	10.3	49.4	58.2
Other Europe*	113.0	145.5	139.6	27.1	13.8	9.0
Africa	0.1	0.1	0.3	17.6	11.3	4.1
Japan	249.2	226.4	211.6	0.1	0.1	0.2
Other Asia	0.4	0.6	0.2	13.1	31.2	11.2
Latin America	–	3.3	–	187.2	158.4	167.2
Middle East	0.3	0.6	0.6	4.5	1.0	3.5
Oceania	35.1	12.2	11.1	12.9	27.5	19.1
Total	1,553.4	1,477.2	1,377.6	1,027.8	1,076.1	1,639.6

Source: Dominion Bureau of Statistics, Trade of Canada.
Note: Products included are those listed in Table 8.
*Includes the USSR in Europe and Asia.
pPreliminary; –Nil; †ECSC European Coal and Steel Community.

TABLE 11

Canada, Steel, Iron, Coke and Sinter Capacity and Production at Integrated Plants [1], 1968
(net tons)

	Algoma		Cominco	Dofasco	Sysco	QIT	Stelco[2]	National
	Sault Ste. Marie	Port Colborne	Kimberley	Hamilton	Sydney	Tracy (Sorel)	Hamilton	Total
Crude Steel								
Facilities, Dec. 31								
Open Hearth								
Number	6	–	–	–	5	–	14	25
Capacity	1,150,000	–	–	–	1,070,000	–	4,750,000	6,970,000
Basic Oxygen								
Number	3	–	– 1	3	–	–	–	7
Capacity	1,450,000	–	80,000	2,270,000	–	–	–	3,800,000
Electric								
Number	–	–	–	5	1	–	–	. .
Capacity	–	–	–	50,850	30,000	–	–	2,344,375
Total Capacity	2,600,000	–	75,000	2,320,850	1,100,000	–	4,750,000	13,114,375
Production	2,261,336	–	. .	2,179,691	869,159	–	4,393,910	11,250,996
Pig Iron								
Facilities, Dec. 31								
Blast Furnaces								
Number	4	1	–	3	2		5	15
Capacity	2,335,000	240,000	–	1,730,000	900,000		3,800,000	9,005,000
Electric Furnaces								
Number	–	–	2	–	–	9	–	11
Capacity	–	–	110,000	–	–	465,000	–	575,000
Total Capacity	2,335,000	240,000	110,000	1,730,000	900,000	465,000	3,800,000	9,580,000
Production	2,072,078	117,197	95,000	1,825,985	684,551	459,295	3,147,017	8,382,601[3]
Coke from Coal								
Facilities								
No. of ovens	260	–	–	158	114	–	264	898
Total Capacity	1,852,000	–	–	950,000	612,000	–	2,100,000	5,964,625
Production	1,523,160	–	–	921,388	159,743[4]	–	1,981,980	5,310,762
Sinter								
Facilities								
No. of Strands	1	–	1	–	1	–	1	8[5]
Total Capacity	725,000	–	300,000	–	250,000	–	900,000	4,415,000
Production	601,851	–	148,000	–	232,056	–	757,753	3,669,157

Source: Company data supplied to Mineral Resources Branch; National total from Dominion Bureau of Statistics.

[1]The seven plants listed accounted for all pig iron and 86 per cent of the crude steel produced in 1968. [2]Stelco also has an electric furnace plant (128,000 tons a year capacity) at Edmonton. [3]Production reported by individual companies exceeds DBS national total. [4]Coke ovens sold to Cape Breton Development Corporation (DEVCO) effective May 1, 1968; production listed is by Sysco in the January-April period only. [5]Includes four strands at Algoma Ore Properties Division, Wawa, Ontario.

– Nil; . . Not available.

The supply of most additive materials, including ferroalloys, was adequate in 1968. A major exception was nickel, which continued to be supplied on allocation to domestic consumers.

Details on raw materials consumed at major integrated steel plants are listed in Table 12.

TABLE 12

Canada, Consumption of Raw Materials at Pig Iron and Integrated Steel Plants [1], 1968
(net tons)

	In Sinter Plants	In Iron and Steel Furnaces		
		Pig Iron Furnaces[2]	Steel Furnaces	Total in Furnaces
Iron Ore				
Crude and concentrate	837,870	875,774[3]	81,436	957,210
Pellets	85,348	8,192,846	257,453	8,450,299
Sinter (from mines)	61,967	1,710,080	–	1,710,080
Total	985,185	10,778,700	338,889	11,117,589
Sinter (produced at plant)	–	1,571,757	148,925	1,720,682
Total iron ore	985,185	12,350,457	487,814	12,838,271
Contained iron	533,371	7,518,844	319,230	7,838,074
Other Iron-Bearing Materials				
Calcine and pyrite	150,070	–	–	–
Flue dust	129,661	–	–	–
Scale, sponge iron, etc.	420,687	66,873	106,278	173,151
Total	700,418	66,873	106,278	173,151
Contained iron	435,589	43,222	104,175	147,397
Other Materials				
Ferromanganese	–	147	75,277	75,424
Pig iron	–	–	7,421,209	7,421,209
Coal	. .	. .	. .	. .
Coke: own make	43,846	4,047,132	258	4,047,390
Purchased	16,350	326,301	230	326,531
Total	60,196	4,373,433	488	4,373,921
Scrap: own make	42,509	79,459	2,767,693	2,847,152
Purchased	3,101	142,125	696,776	838,901
Total	45,610	221,584	3,464,469	3,686,053
Stone: Limestone	96,678	664,695	193,617	858,312
Dolomite	298,823	526,891	108,803	635,694
Total	395,501	1,191,586	302,420	1,494,006
Burnt Stone: Lime	109	–	378,185	378,185
Dolomite	–	–	19,763	19,763
Total	109	–	397,948	397,948

Source: Company data supplied directly to Mineral Resources Branch.
[1]Includes plants listed in Table 11 except QIT. [2]Blast and electric furnaces. [3]Excludes 1,380,236 net tons of ilmenite containing about 460,000 net tons of iron.
–Nil; . .Data confidential, only one consumer.

TABLE 13

Canada, Energy and Reductant Consumption at Major Integrated Steel Plants *, 1968

	Coal (net tons)	Coke (net tons)	Coke Oven Gas (mill. cu. ft.)	Tar and Pitch (000 Imp. gal.)	Natural Gas (mill. cu. ft.)	Fuel Oil (000 Imp. gal.)	Oxygen (mill. cu. ft.)	Electricity (mill. kwh)
In coke ovens**	6,296,808	–	16,287	–	–	–	–	38
In sinter plants	..	60,196	550	–	–	–	–	25
In iron furnaces	..	4,373,433	3,500	..	..	24,445	5	353
In steel furnaces	–	488	3,253	..	..	75,451	12,774	125
In other uses	..	16,315	42,208	..	..	71,021	1,070	1,902
Total Consumption	6,494,750	4,450,432	65,798	4,668	10,630	170,917	13,849	2,443

Source: Data supplied by companies to Mineral Resources Branch.

*Includes all plants listed in Table 11 except QIT. **Excludes coal used by Devco after taking over Sysco coke ovens effective May 1, 1968.

–Nil; . .Included in total, publication would disclose individual company data.

ENERGY AND REDUCTANT MATERIALS

Table 13 lists consumption of selected energy and reductant materials at integrated iron and steel plants in 1968. Although the list is not complete, the use of these materials in various processes is indicated. One significant source of energy, blast furnace gas, is not listed. This gas, recovered from the top of blast furnace stacks and cleaned, contains about one tenth of the energy in natural gas but it is estimated that more than 500 billion cubic feet were used in 1968 by the companies included in Table 13. It is burned in coke ovens, blast furnace stoves, steam boilers, etc. in the plant.

INVESTMENTS AND CORPORATE DEVELOPMENTS

Capital expenditures at iron and steel mills declined for the second consecutive year in 1968 (Table 1) as major expansion programs at a number of steel plants gradually were completed. A record $210.6 million was expended in 1966 compared with $122.9 million in 1967 and $85.8 million in 1968. Repair expenditures rose moderately in 1968, after having declined in 1967. Company announcements in 1968 and early 1969 indicate that another major round of steel industry investment is likely to occur during the next four to five years. Algoma, Dofasco and Stelco all have large projects under way or planned. A survey of industry intentions late in 1968 suggests that capital and repair expenditures in 1969 will be about $149.7 million and $155.5 million, respectively.

THE ALGOMA STEEL CORPORATION, LIMITED

Capital and mine development expenditures totalled $23 million in 1968 compared with $39 million in 1967. Major items completed included a two-strand continuous casting machine for shaped sections and slabs, a slab storage yard, scarfing equipment at the blooming mill and for the new plate and 106-inch hot strip mills, and relining of a blast furnace. Development of new underground and surface coal mines in West Virginia was also completed. Expenditures in 1969 are expected to total $40 million and will include a large number of improvements and additions mainly at Sault Ste. Marie. Main items, some of which were begun in 1968, include continuation of construction of the 160-inch plate mill, conversion of various parts of the plant to natural gas, relining of a blast furnace, a phenol recovery plant, additional equipment for finishing wide hot-rolled sheet and strip, a new ingot mould yard, a number of improvements at blast furnace, rolling and finishing facilities, a new blast furnace turbo-blower, and several pollution abatement installations. Scheduling of the planned new blast furnace and basic oxygen steel furnaces is still under review.

ATLAS STEELS DIVISION OF RIO ALGOM MINES LIMITED

Construction at the Tracy, Quebec stainless steel plant was completed in 1968 with installation of a stream vacuum degassing unit. At Welland, the first stage of a major modernization plan was completed, including a second consumable electrode vacuum arc melt furnace and vacuum annealing facilities. In 1969, construction will begin on a cold-draw installation for alloy bars, new soaking pits and new in-process heating facilities at the billet and bar mill. The program as planned will require capital expenditures of about $30 million over the next few years. As part of the company's research and development program, construction of a pilot-scale electro-slag melting facility began in 1968.

BURLINGTON STEEL DIVISION OF SLATER STEEL INDUSTRIES LIMITED

Major projects completed in 1968 were a 40-ton electric furnace and a three-strand continuous billet casting machine. A second continuous casting machine will be installed in 1969 and the company is considering modernization of rolling facilities and increased plant capacity.

CANADIAN PHOENIX STEEL & PIPE LTD.

The Company completed a second mill and other facilities in Calgary for the production of large diameter line pipe and purchased the spiral-weld pipe plant of Driam Pipe (Canada) Limited at Toronto, which was renamed Canadian Phoenix Steel & Pipe (Toronto) Limited. The company is reported to be considering further steps toward integrating pipe plants with steel producers.

DOMINION FOUNDRIES AND STEEL, LIMITED

Capital expenditures totalled $21.6 million in 1968, mainly on manufacturing facilities, compared with $45.2 million in 1967 when the total was evenly divided between steel plant and mine development. Major items completed in 1968 were a third galvanizing line, normalizing and annealing facilities for electrical steels, a new boiler and two soaking pits for the hot mill. A large blast furnace turbo-blower and a new sheet-products storage building will be completed in 1969. Late in 1968 the company announced a $60-million expansion program to include a fourth blast furnace to raise iron capacity 60 per cent by late 1970, a new pouring floor and other equipment in the steel furnace plant that will increase steelmaking capacity 35 per cent to 2.75 million tons a year, and a second hot roughing mill to raise rolling capacity 35 per cent. Early in 1969, the company announced it had purchased or optioned land totalling 5,000 acres on Lake Erie, 15 miles east of St. Thomas but stated that there are no immediate plans to build facilities on it.

DOMINION STEEL AND COAL CORPORATION, LIMITED

The company's former Sydney, Nova Scotia steelworks was taken over by Sydney Steel Corporation, a provincial Crown corporation, at the beginning of 1968. Late in the year, Sidbec, a company formed by the Province of Quebec, was successful in its offer to purchase at least 90 per cent of the outstanding shares of Dosco. Under an agreement with Hawker Siddeley Canada Ltd. non-steelmaking operations of Dosco were re-purchased by a newly-formed subsidiary of Hawker Siddeley. Remaining assets of Dosco now controlled by Sidbec include the Montreal Works with electric furnaces, merchant rolling mills, and pipe, wire and fastener facilities; the Contrecoeur, Quebec Works with mills for rod, bars and hot strip; and the Etobicoke, Ontario wire and nail plant.

ENAMEL & HEATING PRODUCTS, LIMITED

The company modernized its merchant rolling mill at Amherst, Nova Scotia, raising rolling capacity to 30,000 tons a year.

FINA METAL LTD.

The company completed a $4.1-million iron powder plant at Montreal late in 1968 that is capable of producing up to 16,000 tons of iron powder yearly.

INTERPROVINCIAL STEEL AND PIPE CORPORATION LTD.

The company completed a $2-million large-diameter spiral-weld pipe mill early in 1968. The mill, capable of producing pipe from 16 to 80 inches in diameter, has an annual capacity of about 48,000 tons. The company plans to increase steelmaking capacity from 150,000 to 200,000 tons a year in 1969 through installation of larger furnace transformers.

LAKE ONTARIO STEEL COMPANY LIMITED

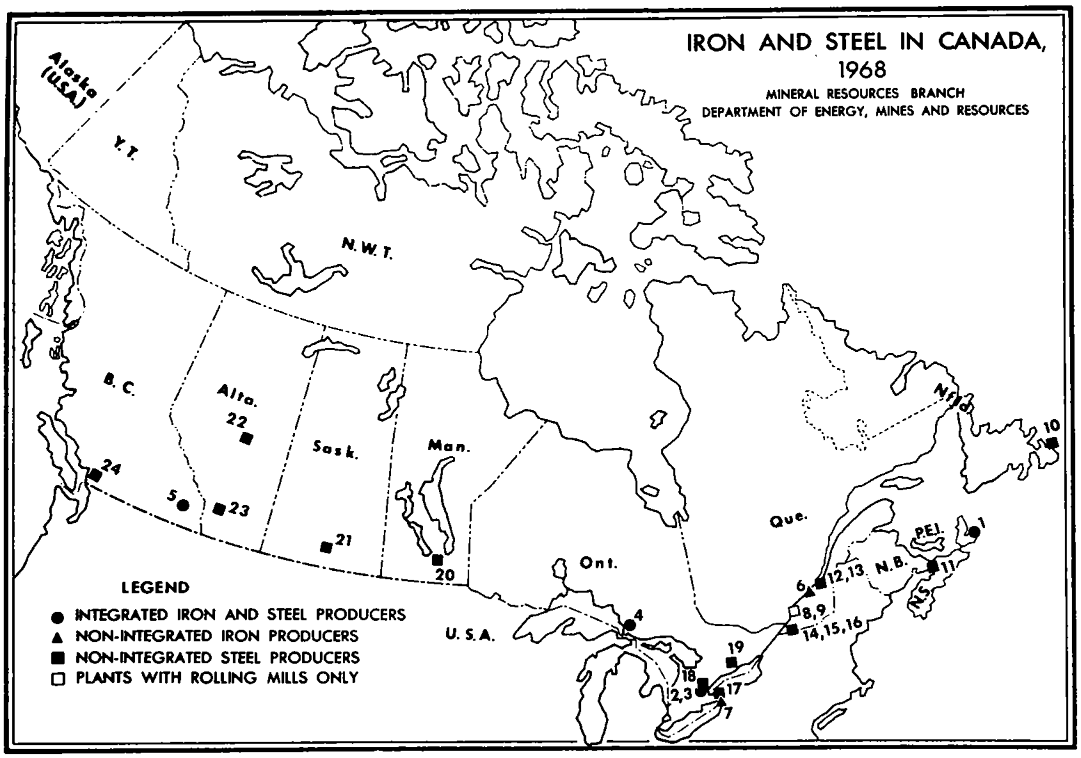
The company has completed a $4-million expansion and diversification program which raised steelmaking capacity to 300,000 tons a year through the installation of larger furnace transformers, and extended the product range into channels and larger angles and flats.

MANNESMANN TUBE COMPANY, LTD.

Mannesmann began a two-stage, $3-million expansion at its Sault Ste. Marie seamless tube plant in 1968. The first phase, completed in 1968, raised finishing capacity while the second, extending into 1969, will raise pipe capacity.

NEWFOUNDLAND STEEL (1968) LIMITED

The assets of Newfoundland Steel Company Limited, which built a small steel plant at Octagon Pond, Nfld. in 1966, were taken over by a provincial



INDEX FOR MAP
IRON AND STEEL IN CANADA, 1968

INTEGRATED IRON AND STEEL PRODUCERS

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)

NON-INTEGRATED IRON PRODUCERS

6. Quebec Iron and Titanium Corporation (Tracy)
7. Canadian Furnace Division of Algoma (Port Colborne)

PLANTS WITH ROLLING MILLS ONLY

8. Dominion Steel and Coal Corporation, Limited (Contrecoeur)
9. The Steel Company of Canada, Limited (Contrecoeur)

NON-INTEGRATED STEEL PRODUCERS
(a partial listing)

10. Newfoundland Steel (1968) Limited (Octagon Pond)
11. Enamel & Heating Products, Limited (Amherst)
12. Atlas Steels Division, Rio Algom Mines Limited (Tracy)
13. Crucible Steel of Canada Ltd. (Sorel)
14. Canadian Steel Foundries Division Hawker Siddeley Canada Ltd. (Montreal)
15. Canadian Steel Wheel Limited (Montreal)
16. Dominion Steel and Coal Corporation, Limited (Montreal)
17. Atlas Steels Division, Rio Algom Mines Limited (Welland)
18. Burlington Steel Division, Slater Steel Industries Limited (Hamilton)
19. Lake Ontario Steel Company Limited (Whitby)
20. Manitoba Rolling Mills Division, 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)

Crown corporation in 1968 after the company experienced financial difficulties. A second grinding ball mill was installed and the company plans to begin fabrication of bars for customers.

PEACE RIVER MINING & SMELTING LTD.

The company is building a $16-million plant near Windsor, Ontario, to produce up to 50,000 tons of iron powder annually. Completion is scheduled for late 1969 or 1970.

QUEBEC METAL POWDERS LIMITED

The company, a subsidiary of Quebec Iron and Titanium Corporation, completed a $10-million plant at Sorel, Quebec to produce up to 70,000 tons of iron powder yearly.

TABLE 14

Canada – Most Favoured Nations Tariff on Selected Iron and Steel

Tariff Item		Before Jan. 1, 1968	On and after Jan. 1, 1968	On and after Jan. 1, 1969	On and after Jan. 1, 1970	On and after Jan. 1, 1971	On and after Jan. 1, 1972
32905-1	Iron ore	free	free	free	free	free	free
37301-1	Iron and steel scrap	"	"	"	"	"	"
37400-1	Pig iron – per ton	$2.50	$2.00	$1.50	$1.00	50¢	"
37700-1	Ingots of iron or steel – per ton	$3.00	$2.40	$1.80	$1.20	60¢	"
37800-1	Semis: blooms, slabs, billets, bars	5%	5%	5%	5%	5%	5%
37900-1	Bars or rods, hot rolled	10%	10%	10%	10%	10%	10%
37905-1	Bars or rods, cold rolled	15%	14½%	14%	13½%	13%	12½%
37915-1	Rods for wire manufacture – per ton	$3.00	$3.00	$3.00	$3.00	$3.00	$3.00
37920-1	Rods for mfg. of wire for fencing – per ton	free	free	free	free	free	free
	Shapes – hot or cold rolled						
38001-1	Angles, beams, channels, tees, zees and other shapes or sections	10%	10%	10%	10%	10%	10%
38002-1	Large sections, not made in Canada – per ton	$5.00	$5.00	$5.00	$5.00	$5.00	$5.00
38100-1	Plate, hot or cold rolled	10%	10%	10%	10%	10%	10%
38201-1	Sheet and strip, hot rolled	"	"	"	"	"	"
38202-1	Sheet and strip, cold rolled	15%	14½%	14%	13½%	13%	12½%
38203-1	Sheet and strip, coated with tin or enamel	"	"	"	"	"	"
38204-1	Sheet and strip, coated with zinc (galvanized)	"	"	"	"	"	"
38205-1	Sheet and strip, other	"	"	"	"	"	"
38400-1	Skelp (plate or sheet for pipe, tubes, hot rolled)	7½%	7½%	7½%	7½%	7½%	7½%
38700-1	Rails	10%	10%	10%	10%	10%	10%
39000-1	Castings	17½%	17%	16½%	16%	15½%	15%
39200-1	Forgings	22½%	20%	19%	18½%	18%	17½%
39900-1	Pipe, large diameter	15%	15%	15%	15%	15%	15%
40101-1	Wire, round, n.o.p.	7½%	7½%	7½%	7½%	7½%	7½%
40102-1	Wire, other than round, n.o.p.	10%	10%	10%	10%	10%	10%
40103-1	Wire coated or covered, n.o.p.	"	"	"	"	"	"

Source: The Custom Tariff and Amendments – Department of National Revenue and Excise.
Details for specific variations can be found in the above source.
n.o.p. Not otherwise provided.

THE STEEL COMPANY OF CANADA, LIMITED

Capital expenditures totalled $33.5 million in 1968 compared with $89.2 million in 1967. Major items completed at the Hilton Works in Hamilton, Ontario included rebuilding of a blast furnace, additional soaking pits, extension of facilities to accommodate increased output of slabs, plate and skelp, and various anti-pollution facilities. At year-end, construction in progress included a new ingot-stripper building and crane, two more soaking pits and additional warehousing space and handling equipment for hot-rolled products. At the Page-Hersey Works in Welland, Ontario, additional equipment was being installed for production of hollow structural sections and a new electric-weld tube mill was under way. Additions and improvements were also being made to rolling mills at the Premier Works at Edmonton, Alberta and the McMaster Works at Contrecoeur, Quebec, and to various facilities at several other plants. Construction of the company's Griffith Mine in northwestern Ontario and expansion of the partly-owned Wabush Mines in Labrador and Quebec were completed in 1968.

A major expansion program to begin in 1969 at the Hilton Works will include three 120-ton basic oxygen furnaces and a third bloom and billet mill. The program, to cost $102 million, will raise steelmaking capacity from 4.5 to six million tons a year by 1971. Existing roughing mill capacity will be released to produce slabs for the 80-inch hot strip mill planned as part of the company's Lake Erie development. The new strip mill will be completed about 1973. It is the initial facility at the Lake Erie development, situated on part of the 6,600-acre site near Nanticoke, Ontario purchased in 1968. It will include a single, reversing roughing stand and six continuous finishing stands. Cost will exceed $100 million. Primary steel-making and steel finishing facilities will be added at a later date.

SYDNEY STEEL CORPORATION

Sysco, a provincially-owned Crown corporation, purchased the assets of Dominion Steel and Coal Corporation, Limited, Sydney Works, after the latter announced plans to close the plant. Sysco assumed management effective January 1, 1969. The coke ovens and associated facilities were sold to Cape Breton Development Corporation as of May 1, 1968. The rod and bar mill was taken out of operation early in 1969 and the company's main steel products are now rails, slabs, blooms and billets. A 10-year, $50-million modernization program is under consideration; it would include installation of basic oxygen steelmaking furnaces, continuous casting facilities and increased rail capacity.

PRICES AND TARIFFS

There were relatively few changes in domestic rolled steel prices in 1968 although there were increases for a number of specialty products. According to *Steel Magazine*, increases covered certain grades of wire (up 8 to 9 per cent), galvanized sheet (1.4 to 4.3 per cent), tinplate (3.7 per cent), blueplate and blackplate (6 to 9.6 per cent), cold-rolled vitreous sheets and bar mill bands (about 3 per cent), and most grades of electrical sheet (2.3 to 14.8 per cent). Prices in the United States were raised moderately on nearly all steel products. Most occurred in August although prices for certain special steels were raised in January and April. Most tinplate prices were raised in October while those for galvanized and aluminized sheets were increased in December. European prices remained low throughout most of 1968 but a gradual strengthening of demand in most countries of the world resulted in some strengthening in prices toward the year end and a rather remarkable increase during the first quarter of 1969.

Canada agreed to reduce its MFN tariffs on certain iron and steel products at the Kennedy Round Negotiations of the General Agreement on Tariffs and Trade. The schedule of reductions agreed upon is shown in Table 14.

Lead

J. G. GEORGE*

In 1968, 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 9 per cent from 1967. Substantial increases in output from British Columbia, Ontario and New Brunswick, together with smaller increases in several other provinces and the Northwest Territories, offset decreases in the Yukon Territory and Manitoba. Higher production at the Sullivan lead-zinc mine operated by Cominco Ltd. in British Columbia and increased byproduct output from the Kidd Creek zinc-copper mine of Ecstall Mining Limited, a wholly-owned subsidiary of Texas Gulf Sulphur Company, near Timmins, Ontario, accounted for most of the 9 per cent rise in total output. Also contributing to the increase was much higher output by Nigadoo River Mines Limited near Bathurst, New Brunswick, which completed its first full year of operations. The value of Canadian output was almost $4.8 million higher than that of 1967.

Primary refined lead output totalled 202,100 short tons compared with 194,814 tons in 1967. Cominco Ltd. operated its smelter and refinery at Trail, British Columbia, at close to capacity of 190,000 tons annually. At Belledune, New Brunswick, East Coast Smelting and Chemical Company Limited, a subsidiary of Brunswick Mining and Smelting Corporation Limited, completed its first full year of production of primary lead metal from an Imperial Smelting Furnace, which has an annual capacity of 33,000 tons. Secondary smelters in 1967, the latest year for which statistics are available, shipped 33,413 tons of antimonial lead and unalloyed lead recovered from secondary materials; shipments in 1966 were 32,454 tons.

Cominco Ltd. processed most of the lead ores and concentrates from western Canada at its Trail plant; 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 East Coast plant, were shipped to smelters in Europe and the United States.

Exports of ores and concentrates were 14 per cent higher than in 1967, with more than a half of them going, in about equal quantities, to the United States and Japan. Metal exports in 1968 were almost 5 per cent higher than in 1967, with the United States and Britain continuing to be the major customers.

Statistics are not available for Canadian consumption of primary and secondary lead metal in 1968, but in 1967 the total consumption was almost 94,000 tons.

UNITED STATES IMPORTS AND STOCKPILES

United States imports of lead metal and lead in ores and concentrates totalled 425,700 tons in 1968, almost 13 per cent less than those of 1967. Substantial reductions occurred in both categories of imports. The curtailment in imports of lead ores

*Mineral Resources Branch.

TABLE 1

Canada, Lead Production, Trade and Consumption, 1967-68

	1967		1968p	
	Short Tons	$	Short Tons	$
Production				
All forms[1]				
Northwest Territories	127,377	35,665,535	130,000	35,152,000
British Columbia	103,827	29,071,522	115,433	31,213,027
New Brunswick	47,017	13,164,585	52,948	14,317,306
Newfoundland	19,940	5,583,296	22,359	6,045,784
Ontario	5,529	1,548,195	14,035	3,795,129
Yukon	7,650	2,141,959	3,518	951,117
Quebec	2,882	806,888	2,992	808,915
Saskatchewan	1,559	436,709	2,352	635,981
Manitoba	1,785	499,797	1,637	442,649
Nova Scotia	397	111,225	1,606	434,507
Total	317,963	89,029,711	346,880	93,796,415
Mine Output[2]	349,300		363,356	
Refined[3]	194,814		202,100	
Exports				
Lead contained in ores and concentrates				
United States	30,299	5,386,000	36,465	6,466,000
Japan	42,634	6,868,000	36,300	5,593,000
West Germany	17,872	2,440,000	29,483	3,821,000
Belgium and Luxembourg	31,512	4,037,000	28,107	4,104,000
Britain	2,625	371,000	7,503	1,050,000
Other countries	1,252	159,000	5,995	992,000
Total	126,194	19,261,000	143,853	22,026,000
Lead in pigs, blocks and shot				
United States	45,604	12,148,000	54,028	13,300,000
Britain	51,179	9,793,000	50,848	10,486,000
Netherlands	9,712	1,853,000	11,350	2,366,000
West Germany	8,587	1,637,000	7,285	1,505,000
India	7,579	1,636,000	6,726	1,422,000
Japan	3,468	681,000	3,777	791,000
Denmark	1,579	305,000	1,440	330,000
Greece	–	–	1,125	219,000
Italy	1,887	367,000	733	150,000
Norway	451	86,000	563	111,000
Other countries	2,274	463,000	906	186,000
Total	132,320	28,969,000	138,781	30,866,000
Lead and lead-alloy scrap (gross weight)				
United States	5,404	987,000	4,483	581,000
Britain	433	98,000	611	118,000
Venezuela	113	19,000	457	70,000
West Germany	–	–	161	194,000
Spain	–	–	16	2,000
Other countries	84	75,000	–	–
Total	6,034	1,179,000	5,728	965,000

TABLE 1 (cont'd)

	1967		1968p	
	Short Tons	$	Short Tons	$
Lead fabricated materials not elsewhere specified				
United States	2,480	855,000	3,325	1,160,000
India	29	21,000	81	62,000
Belgium and Luxembourg	–	–	59	12,000
Other countries	347	76,000	21	60,000
Total	2,856	952,000	3,486	1,294,000
Imports				
Lead pigs, blocks and shot	438	139,000	152	54,000
Lead oxide; litharge, red lead, mineral orange	2,441	711,000	2,633	740,000
Lead fabricated materials, not elsewhere specified	304	252,000	397	319,000
Total	3,183	1,102,000	3,182	1,113,000

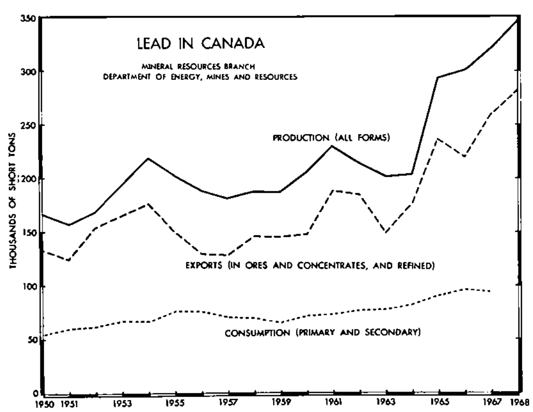
	1966			1967		
	Primary	Secondary[4]	Total	Primary	Secondary[4]	Total
	(short tons)			(short tons)		
Consumption						
Lead uses for, or in the production of:						
Antimonial lead	2,446	17,612	20,058	1,554	15,957	17,511
Battery and battery oxides	21,495	2,539	24,034	21,851	2,207	24,058
Cable covering	5,476	1,914	7,390	4,138	1,385	5,523
Chemical uses: white lead, red lead, litharge, tetraethyl lead, etc.	14,652	2,725	17,377	20,688	3,168	23,856
Copper alloys: brass, bronze, etc.	483	53	536	321	59	380
Lead alloys-solders	2,895	2,849	5,744	2,545	2,089	4,634
- other - (including babbitt, type metal, etc.)	465	2,114	2,579	568	1,749	2,317
Semifinished products: pipe, sheet, traps, bends, blocks for caulking, ammunition, foil, collapsible tubes, etc.	13,665	1,674	15,339	11,256	802	12,058
Other	2,267	1,359	3,626	2,309	1,307	3,616
Total	63,844	32,839	96,683	65,230	28,723	93,953

Source: Dominion Bureau of Statistics.
[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]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.

and concentrates was caused mainly by the nationwide strike in the nonferrous industry from July 1967 until April 1968. Metal imports were lower because of reduced lead production in several foreign countries, caused by a variety of operating difficulties, and increased imports by communist countries. It appeared that the eastern bloc, on balance, absorbed lead from the free world in 1968 whereas in previous years it was a net exporter to the western countries. The longshoremen's strike on the United States' east coast and gulf coast docks, which began late in 1968 and was not settled until mid-February 1969, was also a factor contributing to the reduction of both ore and metal imports.

In April 1965, the United States government authorized the release of 200,000 short tons of lead from its stockpiles, which included 50,000 tons for governmental use only. By mid-1968, the 150,000 tons authorized for sale to industry had been completely disposed of. Consequently, any further release of stockpile lead for commercial sale will require U.S. Congressional approval. The lead inventory in the stockpile at the end of 1968 amounted to some 1.16 million tons, all of which was considered to be surplus to conventional and nuclear war requirements.

In January 1967, Bills H.R. 51 and S. 289, to establish flexible import quotas on lead and zinc ores and metal, were introduced in the House of Representatives and the Senate. Later that year, the two bills were referred to Congressional Committees for further study. About mid-1968, the Ways and Means Committee of the House of Representatives conducted hearings at which testimony was received concerning the legislation proposed in Bill H.R. 51. However, at the end of 1968, both bills 'remained in committee'.



WORLD PRODUCTION AND CONSUMPTION

Non-communist world mine production of lead, according to statistics published by the International Lead and Zinc Study Group, was 2.46 million short tons in 1968, 2.5 per cent higher than in 1967. A substantial increase in output in the United States, together with higher production in Canada, Spain and Peru more than offset declines in the Republic of South Africa, West Germany and some other countries. Canada was the non-communist world's third largest mine producer following Australia and the United States. Non-communist world production of refined lead was an estimated 3.19 million short tons, about 142,700 tons more than in 1967. The United States and Britain reported the largest increases in refined lead production.

Consumption of lead in the non-communist world rose in 1968 to a record of 3.23 million short tons, an increase of more than 5 per cent from 1967. The United States remained the world's largest consumer, using 1.32 million tons or some 76,000 tons more than in 1967. The major increases occurred in the use of lead for storage batteries, gasoline antiknock additives and pigments.

In reviewing the estimates for lead made at its November 1968 meeting in Geneva, Switzerland, the International Lead and Zinc Study Group noted that non-communist world supply and demand were approximately in balance in 1968. For 1969 its forecast was for supplies to grow slightly more than demand which could result in a statistical surplus of about 5 per cent. The Group's forecasts of production in recent years have not generally been fully realized, so that any surplus that might occur could be smaller than forecast. Such surplus would be increased by any disposals that might be made from United States government stocks. Metal production and consumption in 1969 were expected to be 3.5 and 3.3 million short tons, respectively.

Lead smelter capacity was again increased in 1968 with the opening of two new plants in southeast Missouri, U.S.A., with combined annual capacity of 150,000 tons of refined lead. These plants will treat new mine production from that area. A new Imperial Smelting Furnace (ISF) plant was opened in Britain and one in Poland. Production capacity at a smelter in Yugoslavia was expanded from 88,000 to 132,000 tons annually. An ISF plant is scheduled to open in Japan in 1969 and another in Sardinia in 1970. Mexico planned to build its first ISF plant with operations expected to begin in 1970, and a similar plant is planned for installation in Yugoslavia with operations due to start in 1971.

In May 1968, the Magmont lead mine and mill began tune-up operations at Bixby in the New Missouri Lead Belt district of southeastern Missouri. The project is jointly owned by Dresser Industries, Inc. and Cominco American Incorporated, the latter a wholly-owned subsidiary of Cominco Ltd. Full production of 70,000 tons of lead concentrates a year was not expected to be reached until early in 1969. The Buick lead mine, also in southeastern Missouri, was scheduled to begin production early in 1969. It is part

TABLE 2

Canada, Lead Production, Trade and Consumption, 1959-68
(short tons)

	Production		Exports				
	All Forms[1]	Refined[2]	In Ores and Concentrates	Refined	Total	Imports Refined[3]	Consumption[4]
1959	186,696	135,296	53,726	92,252	145,978	1,810	65,935
1960	205,650	158,510	51,336	96,449	147,785	620	72,087
1961	230,435	171,833	70,967	117,637	188,604	1,121	73,418
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	194,814	126,194	132,320	258,514	438	93,953
1968p	346,880	202,100	143,853	138,781	282,634	152	..

Source: Dominion Bureau of Statistics.
[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.

TABLE 3

Non-communist World Mine Production of Lead, 1967-68
(short tons)

	1967	1968p
Australia	410,900	410,900
United States	330,100	369,100
Canada	349,300	363,400
Mexico	182,800	181,000
Peru	174,400	179,700
Yugoslavia	119,000	121,900
Morocco	86,000	..
Spain	68,600	77,500
Sweden	79,000	77,300
Japan	70,000	69,300
Republic of South Africa	77,400	67,100
West Germany	71,300	63,500
Ireland	65,600	61,700
Italy	42,700	39,700
Other countries	276,000	..
Total	2,403,100	2,461,000*

Source: International Lead and Zinc Study Group.
*Total includes estimates for those countries for which figures are not available.
pPreliminary; .. Not available.

of a major mine-mill-smelter complex being built in the same area jointly by American Metal Climax, Inc. and Homestake Mining Company. The Silvermines zinc-lead-silver mine and 3,000-ton-a-day concentrator were brought into production in Ireland in May 1968. In the second half of 1969, the Anvil mine in Canada is expected to start operations at an annual rate of 90,000 tons of lead in concentrates. Large increases in Australia's mine output were planned to begin from 1968 to 1970. Smaller increases in mine output over the next few years were planned in Mexico, Argentina, Bolivia, Peru, Spain, France, Italy, Sweden, Yugoslavia, Morocco, South Africa, Iran, Japan and Korea.

CANADIAN DEVELOPMENTS

YUKON TERRITORY

United Keno Hill Mines Limited in the Mayo district remained the only substantial mine producer of lead in the Yukon. Its mining and milling operations were, however, further reduced because of declining ore reserves, with the concentrator being operated on a single-shift basis throughout 1968. A new shaft was sunk to a depth of 423 feet below the surface collar on the company's Husky claims which are being explored and developed in the vicinity of the Elsa mine. The headframe and shaft house, the hoist-compressor plant and the boiler house were erected. The company also continued development work at the old Sadie Ladue workings. Considerable progress was made during 1968 in development work and construction at the zinc-lead-silver property of Anvil Mining Corporation Limited in the Vangorda Creek area about 130 miles northeast of Whitehorse. Anvil is owned 60 per cent by Cyprus Mines Corporation, Los Angeles, California, and 40 per cent by Dynasty Explorations Limited. By the end of the year, over half of the pre-production stripping at the open-pit mine had been completed, and the construction program was about 50 per cent complete. Production was expected to begin on schedule by late summer of 1969 at an annual rate of 130,000 tons of lead concentrates averaging 69 per cent lead and 240,000 tons of zinc concentrates averaging 54 per cent zinc.

Extensive underground development work was carried out on the gold-silver-lead-zinc property of Venus Mines Ltd. about 18 miles south of Carcross. The company was considering bringing the property into production and erecting a mill with a 300-ton-a-day capacity. Exploration work was done by Atlas Explorations Limited on the silver-lead-zinc-copper showings on their Sheldon and Hess projects in central Yukon. Vangorda Mines Limited did a limited amount of diamond drilling, to obtain fresh samples for metallurgical test work, on its lead-zinc-copper-silver-gold property in the Vangorda Creek area. The deposit's previously estimated tonnage of 9,400,000 tons averaging 3.2 per cent lead, 4.9 per cent zinc, 0.3 per cent copper, 1.76 ounces of silver and 0.02 ounce of gold a ton remained unchanged. Vangorda is controlled by Kerr Addison Mines Limited. A geophysical and geochemical survey carried out on the silver-lead-zinc property of Matt Berry Mines Limited on the east side of the East Arm of Frances Lake outlined several anomalies. The company planned to do further diamond drilling.

NORTHWEST TERRITORIES

Pine Point Mines Limited, 69 per cent owned by Cominco Ltd., was again Canada's largest single mine producer of lead. The lead-zinc orebody at Pine Point, N.W.T., acquired by the company from Pyramid Mining Co. Ltd. in June 1966 was stripped and ready for production on schedule at the end of 1968. The 3,000-ton-a-day addition to the Pine Point concentrator to process the ore from this source was completed and full scale milling tests were run in December 1968.

Texas Gulf Sulphur Company continued exploration work on its Strathcona Sound zinc-lead-pyrite deposit on Baffin Island. Although no further work was done on the mineral claims of Buffalo River Exploration Limited in the Pine Point area, studies were under way to determine the feasibility of bringing the property into production. Previous diamond drilling indicated a deposit of 1,350,000 tons with average grade of 3.4 per cent lead and 9.6 per cent zinc. Buffalo River is owned by Newconex Holdings Limited, Conwest Exploration Company Limited, and Central Patricia Gold 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.

Pine Glacier Mines Ltd. continued mining and milling operations at the Emerald Glacier silver-lead-zinc mine about 50 miles south of Houston in central British Columbia. About mid-1968, the concentrator was milling 60 tons of ore a day. Underground development work continued at the silver-lead-zinc property of Interprovincial Silver Mines Ltd. (name changed from Interprovincial Metals Ltd.) near Atlin in northwestern British Columbia. The company was considering bringing the property into production on a 200-ton-a-day basis. Columbia Metals Corporation Limited continued development and rehabilitation work at its silver-gold-lead-zinc prospect near Ferguson in the southeastern part of the province.

MANITOBA-SASKATCHEWAN

All of the lead produced in Manitoba and some in Saskatchewan came from copper-zinc mines in the Flin Flon and Snow Lake areas operated by Hudson Bay Mining and Smelting Co., Limited. The lead was recovered in a lead concentrate produced at the company's central mill at Flin Flon, Manitoba. Western Nuclear Mines, Ltd. completed its first full year of operations at its Par zinc-lead-copper-silver mine and 350-ton mill at Hanson Lake in northern Saskatchewan.

ONTARIO

Output of lead in Ontario in 1968 was considerably higher than in 1967, mainly because of greater byproduct output at the Kidd Creek silver-base-metal mine of Ecstall Mining Limited near Timmins. Willroy Mines Limited, under the terms of its leasing agreement with Big Nama Creek Mines Limited, began preparing the latter's copper-zinc-lead-silver orebody for production. It was expected that mining operations would begin late in 1969 with the ore to be milled at the Willroy concentrator. The Big Nama deposit adjoins the Willroy mine on the northwest. Willroy also continued exploration and development work on the claims of Slimlake Mines Limited, which adjoin the Willroy property on the north, to explore the projected downward extension of the Big Nama Creek ore zone.

TABLE 4

Principal Lead Producers in Canada, 1968

Company and Location	Mill Capacity (short tons ore/day)	Grade of Ore Milled in 1968 (principal metals) Lead %	Zinc %	Copper %	Silver (oz/ton)	Ore Produced 1968 (1967) (short tons)	Lead in Concentrates and in Direct-Shipping Ores 1968 (1967) (short tons)	Remarks
YUKON TERRITORY - NORTHWEST TERRITORIES								
Pine Point Mines Limited, Pine Point, N.W.T.	8,000	3.5	6.6	–	. .	2,138,000[1] (1,521,000)[1]	137,469 (125,023)	High grade ore shipments terminated at mid-December 1968 with exhaustion of presently available high grade ore reserves.
United Keno Hill Mines Limited, Calumet and Elsa mines, Mayo District, Y.T.	500	6.53	5.55	–	33.93	60,800 (106,189)	3,709 (7,735)	New shaft on Husky claim sunk to 423 feet below the surface collar.
BRITISH COLUMBIA								
Canadian Exploration, Limited, Jersey mine, Salmo	2,150	1.44	3.23	–	. .	506,220 (493,029)	6,690 (4,574)	Routine exploration and development.
Cominco Ltd., Sullivan mine, Kimberley	10,000	. .	. .	–	. .	2,155,749 (2,118,377)	87,178 (90,169)	Cominco's exploration groups continued major exploration programs.
Bluebell mine, Riondel	700	. .	. .	–	. .	251,497 (255,536)	11,171 (11,669)	Routine exploration and development.
Mastodon-Highland Bell Mines Limited, Beaverdell	115	0.80	0.72	–	15.45	36,413 (34,020)	292 (502)	Bell and Beaver workings rehabilitated for future exploration and mining.
Reeves MacDonald Mines Limited, Remac	1,200	1.11	3.68	–	. .	309,311 (404,782)	2,820 (2,768)	Began sinking new exploration shaft on company's nearby Annex property across Pend d'Oreille River.
Utica Mines Ltd., Keremeos	350	. .	. .	–	. .	128,652 (38,442)	103 (40)	Completed first full year of operations.
Western Mines Limited,[2] Myra Falls, Vancouver Island	1,000	0.89	9.26	1.89	2.15	330,223 (230,036)	. . (. .)	New ore developed in 1968 fiscal year was almost sufficient to replace quantity mined.
MANITOBA - SASKATCHEWAN								
Hudson Bay Mining and Smelting Co., Limited	6,000 (treated at central mill at Flin Flon)							

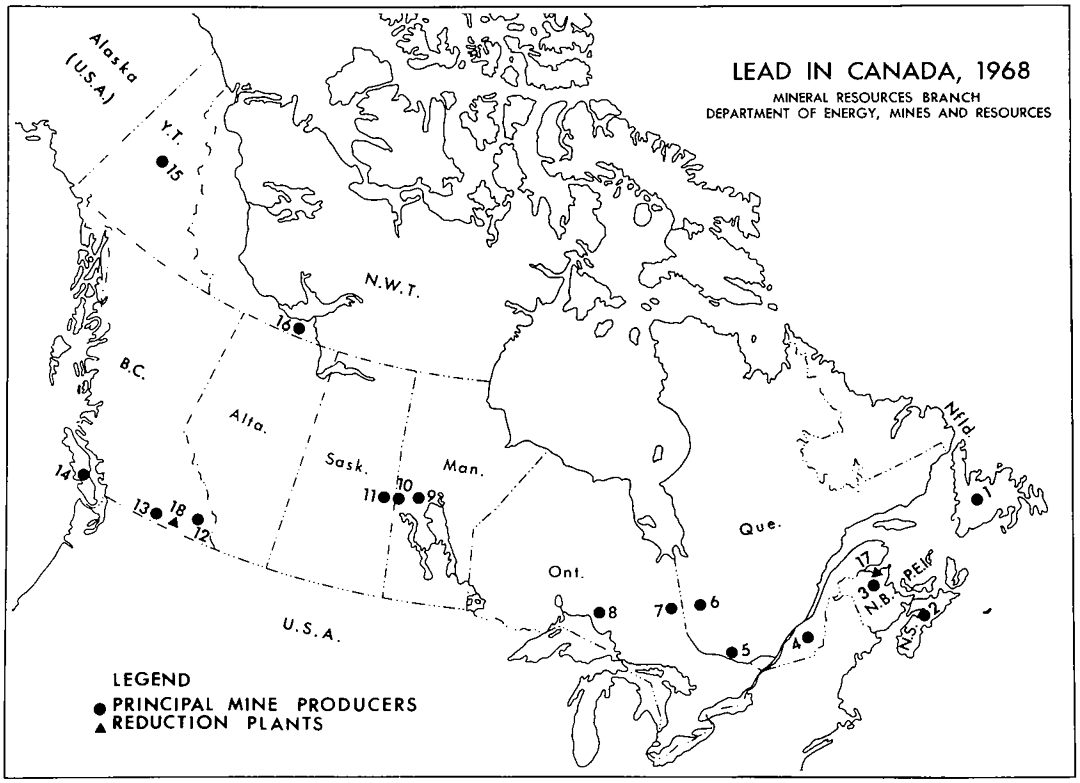
TABLE 4 (cont'd)

Company and Location	Mill Capacity (short tons ore/day)	Grade of Ore Milled in 1968 (principal metals) Lead %	Zinc %	Copper %	Silver (oz/ton)	Ore Produced 1968 (1967) (short tons)	Lead in Concentrates and in Direct-Shipping Ores 1968 (1967) (short tons)	Remarks
Flin Flon mine, Flin Flon, Man.		0.2	3.1	2.4	0.8	806,500 (943,811)	1,507[3] (1,821)[3]	An active development program was in progress throughout the year.
Chisel Lake mine, Snow Lake, Man.		0.7	14.4	0.6	1.1	278,400 (254,118)		
Western Nuclear Mines, Ltd., Hanson Lake mine, Hanson Lake, Saskatchewan	350	6.32	10.89	0.48	2.89	60,789 (41,898)	2,717 (1,592)	Routine exploration and development.
ONTARIO								
Ecstall Mining Limited (Texas Gulf Sulphur Company), Kidd Creek mine, Timmins	9,000	0.50	9.55	1.57	5.19	3,614,860 (3,039,219)	12,454 (5,000)	Program for development of underground mining operation was in early planning stage.
Noranda Mines Limited (Geco Division), Manitouwadge	4,000	. .	4.67	2.18	2.20	1,495,369 (1,461,000)	1,257 (1,128)	Company plans surface diamond drilling on north part of its property.
Willecho Mines Limited, Lun-Echo mine, Manitouwadge	Ore custom-milled	0.26	3.43	0.44	2.15	346,444 (338,437)	624 (564)	Ore treated at Willroy mill. Company completed conveyor installation for lower levels.
Willroy Mines Limited, Manitouwadge	1,700	0.08	2.10	0.96	0.77	174,336 (165,053)	96 (165)	Exploration drive on Slimlake property advanced 1,643 feet. Began underground development of Big Nama Creek orebody.
QUEBEC								
Cupra Mines Ltd., Cupra mine, Stratford Centre	1,500	0.47	3.75	2.81	1.21	225,702 (308,347)	359 (1,156)	Routine exploration and development.
Manitou-Barvue Mines Limited, Golden Manitou mine, Val d'Or	1,300	0.072	2.21	. .	0.81	181,250 (181,350)	107 (223)	Copper and zinc ore milled separately.
		–	–	0.82	0.14	285,160 (294,640)	– (–)	
New Calumet Mines Limited, Calumet Island	800	2.06	6.64	. .	4.18	70,476 (90,779)	1,389 (1,881)	Mining and milling operations ceased October 31, 1968.
Solbec Copper Mines, Ltd., Stratford Centre	Ore custom-milled	0.87	4.59	1.30	1.85	262,076 (75,310)	1,563 (524)	Routine exploration and development. Ore treated at Cupra mill.

TABLE 4 (cont'd)

NEW BRUNSWICK								
Brunswick Mining and Smelting Corporation Limited, No. 12 mine, Bathurst	5,000	3.38	8.56	0.27	1.92	1,724,465 (1,669,000)	38,509 (36,774)	Operations at company's mining, milling and smelter complex continued to improve.
No. 6 mine, Bathurst	2,500	2.47	5.66	0.35	1.53	984,280 (867,400)	18,256 (17,269)	
Heath Steele Mines Limited, Newcastle	1,500[4]	1.55	4.89	1.19	. .	391,363 (308,866)	3,491 (6,166)	Began utilizing total mill capacity to treat company's own ores.
Nigadoo River Mines Limited, Bathurst	1,000	2.46	2.44	0.32	3.33	284,867 (22,630)	6,067 (359)	Completed first full year of operations.
NOVA SCOTIA								
Dresser Minerals, Division of Dresser Industries, Inc., Walton	125	3.80	0.26	0.40	7.10	49,786 (50,330)	1,895 (1,749)	Continued normal underground exploratory diamond drilling.
NEWFOUNDLAND								
American Smelting and Refining Company (Buchans Unit), Buchans	1,250	7.14	12.83	1.11	3.93	378,000 (378,000)	25,595 (27,301)	Routine exploration and development.

Source: Company reports.
[1]Figures represent tons of ore milled. In 1968, company also shipped 353,000 tons of direct-shipping ore of grade averaging 19.0 per cent lead and 25.0 per cent zinc. [2]Production for fiscal years ending September 30. [3]Lead content of lead concentrates only. [4]Part of Heath Steele's mill capacity used to treat copper ore from nearby Wedge mine operated by Cominco Ltd.
– Nil; . . Not available.



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 (Nos. 12 and 6 mines)
   Heath Steele Mines Limited
   Nigadoo River Mines Limited
4. Cupra Mines Ltd.
   Solbec Copper Mines, Ltd.
5. New Calumet Mines Limited
6. Manitou-Barvue Mines Limited
7. Ecstall Mining Limited
8. Noranda Mines Limited (Geco Division)
   Willecho Mines Limited
   Willroy Mines Limited
9. Hudson Bay Mining and Smelting Co., Limited (Chisel Lake mine)
10. Hudson Bay Mining and Smelting Co., Limited (Flin Flon mine)
11. Western Nuclear Mines, Ltd.
12. Canadian Exploration, Limited
    Cominco Ltd. (Sullivan and Bluebell mines)
    Reeves MacDonald Mines Limited
13. Mastodon-Highland Bell Mines Limited
    Utica Mines Ltd.
14. Western Mines Limited
15. United Keno Hill Mines Limited
16. Pine Point Mines Limited

REDUCTION PLANTS

17. East Coast Smelting and Chemical Company Limited
18. Cominco Ltd.

QUEBEC

Lead production in Quebec remained small with the two principal producers being Solbec Copper Mines, Ltd. at Stratford Centre in the Eastern Townships and New Calumet Mines Limited near Campbell's Bay. After operating on a salvage basis for several months, the New Calumet mine finally ceased mining and milling operations on October 31, 1968. Shaft sinking and other development work continued at the base-metal property of D'Estrie Mining Company Ltd. at Stratford Centre in the Eastern Townships. The company, controlled by the Sullivan group of companies, planned to bring the property into production late in 1969 with the ore to be milled at the nearby Cupra concentrator.

NEW BRUNSWICK

The program of new construction and alterations continued at the smelter complex of East Coast Smelting and Chemical Company Limited at Belledune. It includes lead refinery extension and revisions, and improvements to the furnace feed-preparation systems. Intermittent operations at much below full capacity resulted in an output of only 11,800 tons of refined lead in 1968.

Ore production increased substantially, as a result of a mine development and shaft sinking program, at the zinc-copper-lead-silver property of Heath Steele Mines Limited, 40 miles northwest of Newcastle. Treatment of custom ore from another nearby mine ceased in May 1968 and Heath Steele replaced this ore with production from its own mine. Exploration studies in 1968 confirmed sufficient ore reserves to double the mine production rate to 1,000,000 tons of combined zinc-copper-lead ore a year and to sustain this rate for at least 20 years. Construction and installation of equipment required for this expansion was scheduled for completion in 1969.

Further metallurgical test work was carried out at the lead-zinc-silver property of Restigouche Mining Corporation, Ltd., about 70 miles west of Bathurst, to improve concentrate grade and recovery. The company was negotiating for suitable terms of purchase for the expected output of concentrates and, if successful, it planned to bring the property into production at a rate of 1,000 tons a day. The deposit contains 3,270,000 tons grading 4.6 per cent lead, 5.9 per cent zinc, and 2.45 ounces of silver a ton. Chester Mines Limited, a subsidiary of the Sullivan group of companies, did additional geophysical surveys and diamond drilling on its copper-zinc-lead property in the district of Newcastle.

USES

Lead has many useful chemical and mechanical properties and because of this versatility it has a variety of industrial applications. It is soft, ductile, malleable and easily worked. Lead 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 are 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 improvements 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 1968 accounted for considerably more than half the 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 anti-vibration pads are now being widely used 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 anti-fouling 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 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.

TABLE 5

United States Consumption of Lead by End-Use, 1967-68
(short tons)

	1967	1968p
Batteries	466,665	500,157
Gasoline antiknock additives	247,170	261,897
Pigments	103,190	108,650
Solder, type metal, terne metal and bearing metals	118,568	111,608
Ammunition and collapsible tubes	90,065	90,056
Caulking	48,789	47,540
Cable sheathing	63,037	53,316
Sheet and pipe	46,947	43,879
Miscellaneous	76,085	64,489
Estimated undistributed consumption	–	37,500
Total	1,260,516	1,319,092

Source: United States Bureau of Mines Mineral Industry Surveys, Lead Industry in December 1968.
pPreliminary; – Nil.

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

The Canadian lead price, f.o.b. Toronto and Montreal, was 14 cents a pound from the beginning of 1968 until May 3 when it declined to 13 cents. On October 18 the price moved upward to 13.5 cents and remained at this level for the rest of the year. The United States domestic price for common lead, f.o.b. New York, was 14 cents a pound from the beginning of 1968 until May 2 when it dropped to 13 cents. A second reduction to 12.5 cents occurred on June 15. On October 11 the New York price was raised to 13 cents and this quotation obtained for the rest of the year. On January 2, 1968 the London Metal Exchange (LME) settlement and cash seller's price was £93.75 per long ton (10.0 cents a pound Can.). Throughout 1968 it displayed a generally rising trend. The low and high prices for the year were £91.5 (9.8 cents Can.) on January 9 and £109 (11.7 cents Can.) on August 26.

TARIFFS*

	Most Favoured Nation
CANADA	
Ores of metals, n.o.p.	free
Lead, old, scrap, pig and block	free
Lead, in bars and in sheets	8%
UNITED STATES	
All lead-bearing ores	0.75¢ per lb on lead content
Unwrought lead:	
Lead bullion	1.0625¢ per lb on 99.6% of the lead content
Other	1.0625¢ per lb on lead content
Lead waste and scrap	1.0625¢ per lb on 99.6% of the lead content

Sources: The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa.
Tariff Schedules of the United States Annotated (1969) T.C. Publication 272.
* On and after January 1, 1969.
n.o.p. – not otherwise provided for.

Lime and Limestone

D. H. STONEHOUSE*

Carbonate rocks, commonly known as limestones, can be classified according to their content of the minerals calcite ($CaCO_3$) and dolomite ($CaCO_3.MgCO_3$). 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. A calcium or high-calcium limestone is required for cement manufacture where a low magnesia content is essential. Both calcium and magnesian limestones are used to make quicklime (CaO) and hydrated lime ($Ca(OH)_2$). Physical properties influence its use as a building stone or as a crushed stone. Limestone is often used as a crushed stone because it is available near major urban centres where the markets exist and because it is mined, crushed and sized with somewhat less expense than harder rock – sometimes by or in close association with companies producing lime or cement. Approximately 80 per cent of the volume of crushed stone produced in Canada is limestone and the total volume of limestone produced for all purposes represents about 85 per cent of the production of stone of all kinds.

Nearly all of Canada's production of limestone is used in some phase of the construction industry. Although the total value of construction during 1968 increased about 9.0 per cent over that for 1967, the amount of lime and limestone input to the industry did not necessarily increase in that proportion.

Non-construction uses for limestone absorb between 6 and 9 per cent of total limestone production and include use in the metallurgical, pulp and paper, sugar refining, glass manufacturing and chemical industries.

Of the six major raw materials used in the manufacture of portland cement, limestone accounts for about 83 per cent of total by weight; this amount represents less than 15 per cent of total limestone production. Approximately 4 per cent of total limestone production is utilized in the production of lime.

OPERATIONS IN CANADA

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

*Mineral Resources Branch.

TABLE 1

Canada, Lime Production and Trade 1967-68

	1967		1968p	
	Short Tons	$	Short Tons	$
Production*				
By type				
Quicklime	1,178,109	13,382,937	1,143,332e	..
Hydrated lime	244,790	3,184,260	222,656e	..
Total	1,422,899	16,567,197	1,365,988	17,086,528
By Province				
Ontario	974,458	11,101,674	915,744	11,118,618
Quebec	337,374	3,492,396	325,615	3,777,536
Alberta	62,821	1,142,619	71,043	1,266,364
Manitoba	45,364	753,263	50,976	854,600
New Brunswick	2,882	77,245	2,610	69,410
Total	1,422,899	16,567,197	1,365,988	17,086,528
Imports				
Quick and hydrated				
United States	21,950	445,000	24,691	513,000
Britain	147	3,000	59	2,000
France	16	6,000	20	11,000
Total	22,113	454,000	24,770	526,000
Exports				
Quick and hydrated				
United States	87,652	1,006,000	84,382	986,000
Bahamas	393	10,000	265	6,000
Bermuda	404	7,000	255	5,000
Panama	–	–	197	4,000
Guyana	1,500	16,000	150	1,000
Other countries	176	4,000	14	...
Total	90,125	1,043,000	85,263	1,002,000

Source: Dominion Bureau of Statistics.
*Shipments and quantities used by producers. In 1967, 916,762 tons were shipped and 506,137 tons were used at the producing plants.
pPreliminary; eEstimated; . . .Less than $1,000.
. .Not available; –Nil.

Ontario and Quebec together produced about 91 per cent of Canada's total lime output in 1968, with Ontario contributing two thirds of Canada's total. More limited markets in the other provinces result 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 1968 in Newfoundland, 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 1968, 18 companies operated a total of 24 lime plants in Canada: 1 in Newfoundland, 1 in New Brunswick, 4 in Quebec, 11 in Ontario, 3 in Manitoba and 4 in Alberta. A total of 94 kilns was maintained – 19 rotary, 72 vertical, 1 vibratory grate and 2 rotary grate. Some captive production is not recorded in Table 1, such as that from a number of pulp and paper plants that burn sludge to recover lime for re-use in the causticization operation, and that produced by a large iron and steel complex for its own use.

MARITIME PROVINCES

Precambrian limestone in the Saint John, New Brunswick area has been the source of raw material for lime manufacture and for the production of crushed

TABLE 2
Canada, Limestone Production, Trade, and Consumption 1966-68

	1966		1967		1968p	
	Short Tons	$	Short Tons	$	Short Tons	$
Production[1]						
By province						
Newfoundland	21,273	85,324	–	–	–	–
Quebec	41,274,290	41,398,707	28,478,460	30,319,188	28,608,749	29,017,042
Ontario	23,594,036	27,964,427	24,088,653	27,218,197	26,296,923	29,973,826
British Columbia	2,313,145	3,529,708	1,958,587	3,354,619	3,284,656	4,809,756
Manitoba	2,019,370	3,312,682	1,771,287	2,863,814	1,553,925	2,899,678
Saskatchewan	–	–	–	–	15	100
New Brunswick	314,484	1,019,201	323,113	872,219	222,700	671,000
Alberta	142,973	492,006	139,163	483,480	140,206	571,492
Nova Scotia	285,000	926,167	237,337	827,814	236,000	828,000
Total	69,964,571	78,728,222	56,996,600	65,939,331	60,343,174	68,770,894
Exports						
Crushed limestone and refuse						
United States	1,150,165	1,939,000	1,339,436	2,071,000	1,706,918	2,462,000
Bahamas	–	–	33	1,000	–	–
Total	1,150,165	1,939,000	1,339,469	2,072,000	1,706,918	2,462,000
Stone, crude, not elsewhere specified						
United States	193,661	393,000	78,216	285,000	252,445	258,000
Ceylon	245	4,000	24	1,000	–	–
Barbados	–	–	10	1,000	–	–
Other countries	6,471	61,000	–	–	151	6,000
Total	200,377	458,000	78,250	287,000	252,596	264,000
Imports						
Stone, crushed, including stone refuse						
United States	1,437,105	3,571,000	1,300,828	3,411,000	1,375,884	3,201,000
Italy	5,157	65,000	5,316	62,000	3,433	52,000
Other countries	86	2,000	–	–	263	13,000
Total	1,442,348	3,638,000	1,306,144	3,473,000	1,379,580	3,266,000
Limestone flux and calcareous stone, used for manufacturing of lime and cement[2]						
United States	1,172,900	3,071,465	1,132,857	3,246,242	1,287,784	3,118,624
Consumption						
In production of cement	12,374,564		10,713,000e		11,094,000e	
In production of lime	2,800,000e		2,561,000e		2,459,000e	
Miscellaneous	69,964,571		56,996,600		60,343,174	
Total	85,139,135		70,270,600		73,896,174	

Source: Dominion Bureau of Statistics.
[1]Producers' shipments plus quantities used by producers. Does not include limestone produced for lime and cement but does include marl used for agricultural purposes.
[2]U.S. Department of Commerce, United States Exports of Domestic and Foreign Merchandise (Report FT 410). Values are in U.S. dollars.
pPreliminary; –Nil; eEstimated.

stone for many years. The limestone is highly metamorphosed, steeply dipping and associated with slate, quartzite and granitic rocks. Lenses of high-purity limestone occur in what is mostly impure limestone. At Saint John, Snowflake Lime, Limited, by selective mining, produces high-calcium limestone; the plus 4-inch material is used to feed the company's lime kilns and the minus 4-inch material is crushed, screened, sized and shipped, mostly by truck, as a clean crushed stone for use as an aggregate, highway chips or for other construction applications. Snowflake's lime production has been small, generally supplying a comparatively local market in competition with Quebec producers. A fire destroyed the company's calcining plant in late 1968 and plans for rebuilding have not been announced.

At Aguathuna, near Stephenville, Newfoundland, Sea Mining Corporation Limited mines a hard, dense, grey, high-calcium limestone of Middle Ordovician age for lime production required in the company's sea-water magnesia operation.

According to railway freight traffic data, over 23,000 tons of lime was off-loaded in the Maritime Provinces during 1968, indicating markets for at least that amount of lime, exclusive of any volume which is moved by truck. Investigations are being conducted in at least two areas of the Maritimes into the feasibility of lime production. There is no question of obtaining high quality raw material; the uncertainties of marketing are the major deterrent to such an undertaking.

Limestone production in the Maritimes during 1968 totalled 458,700 tons for non-cement, non-lime uses. Cement manufacturers used another 600,000 tons of limestone and lime manufacturers consumed about 5,000 tons.

QUEBEC

Limestone occurs mostly in the St. Lawrence River and Ottawa River valleys and in the Eastern Townships. Other major deposits 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. For a number of years quarries have been operated in deposits yielding high-calcium limestone mostly of Ordovician age. Small operations, usually crushed stone businesses, have come and gone but major producers built around the lime or cement manufacturing industries have survived even the smothering effects of an urban spread which they themselves have helped to create.

At Joliette, Domtar Chemicals Limited, Lime Division, produces quicklime and hydrated lime from high-calcium limestone of the Trenton formation at the same location where the original company – Standard Lime Company, Limited – operated in the early 1900's. The Domtar plant is completely modern having a straight rotary kiln that produces lime primarily for the steel industry and a grate-rotary kiln that produces high-calcium lime chiefly for the pulp and paper industry. A completely new hydrating section is under construction. A 400 tph crushing and screening plant produces kiln feed, crushed stone for the construction industry and pulverized agricultural limestone.

At Lime Ridge, Dominion Lime Ltd. produces limestone and lime from a deposit of metamorphosed, high-calcium, fine-grained limestone of Silurian age that was mined as far back as 1834. The company produces high-calcium quicklime for use in pulp and paper mills, steel plants and the construction industry. Hydrated lime and specialty product are marketed also. A crushing and screening plant is operated to provide crushed stone from some impure limestone and pulverized limestone is produced for agricultural use.

A high-calcium limestone of the Beekmantown formation of Ordovician age has been mined for many years by the Quarry Division of Shawinigan Chemicals 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 highly acceptable material for the production of calcium carbide. Modern techniques and equipment for quarrying, crushing, screening, handling and transporting are used to provide "carbide" stone, crushed stone and pulverized "Agstone". Hydrated lime made during calcium carbide – acetylene manufacture is sold for commercial use.

Aluminum Company of Canada, Limited produced magnesia and lime from a brucitic limestone deposit at Wakefield until the end of February, 1968 at which time the plant was closed.

Lime is produced for captive use by Quebec Sugar Refinery at St. Hilaire.

Limestone for non-cement, non-lime use totalled 28,608,749 tons during 1968, according to preliminary figures. Cement manufacturers used about 3,200,000 tons and the lime industry used approximately 600,000 tons.

ONTARIO

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. The limestone industries of Ontario are described in detail by D.F. Hewitt in two publications, *Industrial Mineral Report No. 5 and No. 13,* issued by the Ontario Department of Mines.

Domtar Chemicals Limited, Lime Division, operates a limestone quarry and a lime plant at Beachville. The high-calcium limestone is mined, crushed, screened and used primarily as feed to the lime plant which has both vertical and rotary kilns. Some stone is produced for flux, for cement plants and as pulverized limestone for agricultural uses. At Hespeler, Domtar produces lime, crushed stone and agricultural limestone. The lime plant has vertical kilns and produces high-quality, white, quicklime. Both plants also produce hydrated lime.

For many years Cyanamid of Canada Limited has operated a quarry at Beachville to supply chemical-grade limestone to the company's lime plant at Niagara Falls where a battery of 7 rotary kilns produces 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 and made operative during 1968. Lime manufacture accounts for about half of 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 is supplied with flux stone and with high-calcium lime from a quarry and lime plant near Ingersoll. New vertical kilns were installed at the lime plant in 1959. Flux stone for both open hearth and blast furnace use is screened from crushed rock; various sizes of crushed stone are produced as well as feed for cement production and a pulverized stone for use as a sinter flux stone.

Canadian Gypsum Company, Limited produces a dolomitic lime near Guelph. Coarse stone from the screening plant is fed into vertical kilns and minus 3½-inch material is further processed and sold as crushed stone.

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. A thick cap rock of dolomitic limestone together with the finer fractions of high-calcium limestone are crushed and screened for marketing as crushed stone.

Bonnechere Lime Limited produces a small amount of lime at a single-kiln operation at Carleton Place. Other kilns at Eganville have not been used recently.

Early in 1969 Reiss Lime Company of Canada, Limited began construction of docking facilities on Lake Huron, just west of Spragg, to import limestone from the Rogers City area in Michigan for the manufacture of lime for use in uranium processing.

Limestone production in Ontario in 1968 was 26,296,923 tons for non-cement, non-lime uses, approximately 4,300,000 tons for cement manufacture and about 1,650,000 tons for lime manufacture.

WESTERN PROVINCES

From east to west through the southern half of Manitoba 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 limestones 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 the mottled, dolomitic limestone known as Tyndall Stone and often referred to as "tapestry" stone. This stone has found wide acceptance as an attractive building stone.

Limestone is mined in Manitoba to supply raw material for cement plants in both Manitoba and Saskatchewan, for use by metallurgical and chemical plants, pulp mills, sugar refineries and for many other uses including crushed stone.

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 operated, replacing it with a modern lime manufacturing facility at Ft. Whyte, a suburb of Winnipeg. Limestone is trucked to Ft. Whyte where conventional processing equipment is used in conjunction with a vibratory-grate calciner which offers maximum control of the calcining operation. Quicklime is supplied to chemical, metallurgical and construction industries and limestone is supplied to The Manitoba Sugar Company, Limited for calcining to produce lime for captive use.

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.

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 is quarried about 7 miles west of the plant site to provide kiln feed for production of quicklime and hydrated lime. A pulverized limestone product is marketed for agricultural use.

Summit Lime Works Limited ships high-calcium limestone for use at sugar refineries, dolomitic and high-calcium stone for metallurgical use, and produces a high-calcium quicklime and hydrated lime for the chemical, metallurgical and construction industries.

TABLE 3

Canada, Consumption of Lime, 1966-67
(producers' shipments by use)

	1966		1967	
	Short Tons	$	Short Tons	$
Chemical and Metallurgical				
Iron and steel plants	278,420	3,233,000	277,440	3,237,462
Pulp mills	171,688	2,056,000	175,109	2,137,633
Uranium plants	39,144	441,000	60,366	684,288
Nonferrous smelters	83,337	592,000	66,928	491,384
Sugar refineries	36,161	621,000	31,840	515,945
Cyanide and flotation mills	19,231	279,000	37,686	351,670
Glass works	3,901	45,000	3,805	42,090
Fertilizer plants	4,476	54,000	9,710	111,636
Tanneries	6,017	81,000	3,864	63,846
Water and sewage treatment	31,556	526,000	35,763	562,843
Other	647,542	6,751,000	543,319	5,698,456
Construction				
Finishing lime	81,994	1,708,000	65,982	1,349,386
Mason's lime	33,431	411,000	28,130	410,004
Sand-lime brick	32,734	414,000	30,660	306,531
Agricultural	13,321	193,000	10,784	154,879
Road stabilization	11,268	204,000	4,363	77,789
Other	60,816	731,000	37,150	371,355
Total	1,555,037	18,340,000	1,422,899	16,567,197

Source: Dominion Bureau of Statistics.

The limestone is obtained from a number of quarry sites in the Crowsnest area in the near vicinity of the lime plant.

There is no production of commercial lime in British Columbia although large volumes of limestone are mined annually 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 for cement manufacture.

Limestone produced in the western provinces for non-cement, non-lime use in 1968 totalled 4,978,802 tons. Cement production used about 3,000,000 tons and lime operations absorbed about 200,000 tons.

USES, CONSUMPTION AND TRADE

Limestones are widely distributed in Canada and generally are available in sufficient quantity and with the chemical or physical specifications such 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 51 per cent used as road metal (broken, screened stone for macadam roads), 14 per cent used as concrete aggregate and about 3 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 ammonia, 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

TABLE 4

Canada, Consumption of Limestone, 1966
(producers' shipments by use)

	1966	
	Short Tons	$
Production of cement	12,374,564	. .
Production of lime	2,800,000e	. .
Metallurgical	2,515,296	3,426,176
Pulp and paper	333,793	1,118,519
Glass	114,055	430,788
Sugar refining	75,274	145,677
Other chemical uses	411,554	529,773
Pulverized for agricultural use	1,823,307	4,286,160
Pulverized for other uses	1,593,037	1,498,823
Road metal	40,681,074	40,924,772
Concrete aggregate	14,385,363	15,197,334
Rubble and riprap	878,904	880,355
Railroad ballast	1,883,641	1,997,116
Structural[1]	77,070	3,324,702
Other uses	5,192,203	4,968,027
Total	85,139,135	. .

Source: Dominion Bureau of Statistics.
[1]Includes building, monumental and ornamental stone as well as flagstone and curbstone.

[e]Estimated; . . Not available.

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 by Dominion Magnesium Limited, at Haley, Ontario. The company uses a high-calcium lime from southeastern Ontario in the production of calcium metal. Dead-burned dolomitic limestone, for use as a refractory, is produced by Steetley of Canada Limited at Dundas, Ontario.

The largest single use for lime is as a flux in steel production. The pulp and paper industry is the second largest consumer of lime, most of which is used for the preparation of cooking chemicals in pulp manufacture and for pulp bleaching. A.S.T.M. specifications covering the use of lime in the pulp and paper industry include the following: C 46-62 (Quicklime and Limestone for Sulphite Pulp Manufacture), C 433-63 (Quicklime and Hydrated Lime for Hypochlorite Bleach Manufacture) and C 45-25 (1961) (Quicklime and Hydrated Lime for Cooking of Rags in Paper Manufacture).

TABLE 5

Canada, Lime Production, Trade, Apparent Consumption, 1959-68
(short tons)

	Production[1]			Imports	Exports	Apparent Consumption[2]
	Quick	Hydrated	Total			
1959	1,359,666	326,059	1,685,725	31,424	24,641	1,692,508
1960	1,213,597	315,971	1,529,568	33,820	21,668	1,541,720
1961	1,142,354	272,936	1,415,290	38,453	31,197	1,422,546
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
1968p	1,143,332	222,656	1,365,988	24,770	85,263	1,305,495

Source: Dominion Bureau of Statistics.
[1]Producers' shipments and quantities used by producers. [2]Production plus imports, less exports.
[p]Preliminary.

TABLE 6

Canada, Limestone Consumption, 1958-1968

Year	Cement Mfg.	Lime Mfg.	Miscellaneous*	Total
1958	8,473,596	2,831,886	30,335,004	41,640,486
1959	8,175,733	3,062,152	36,691,804	47,929,689
1960	7,965,872	2,669,574	36,475,371	47,110,817
1961	8,145,376	2,592,831	38,220,418	48,958,625
1962	9,294,196	2,668,480	41,623,473	53,586,149
1963	9,384,412	2,703,709	51,021,396	63,109,517
1964	10,275,353	2,710,253[r]	57,019,890	70,005,496[r]
1965	11,517,771	2,927,691	62,178,833	76,624,295
1966	12,374,564	2,800,000[e]	69,964,571[r]	85,139,135[r]
1967	10,713,000[e]	2,561,000[e]	56,996,600	70,270,600[e]
1968[p]	11,094,000[e]	2,459,000[e]	60,343,174	73,896,174[e]

Source: Dominion Bureau of Statistics.
*Includes limestone used for metallurgical, chemical, agricultural and construction purposes.
[e]Estimated; [r]Revised; [p]Preliminary.

The uranium industry uses lime to control hydrogen-ion concentration during uranium extraction, to recover sodium carbonate and to neutralize waste sludge. In the production of beet sugar, lime is used to precipitate impurities from the sucrate. It is used also in the manufacture of many materials such as calcium carbide, calcium cyanamide, calcium chloride, fertilizers, insecticides, fungicides, pigments, glue, acetylene, precipitated calcium carbonate, calcium hydroxide, calcium sulphate, magnesia and magnesium metal.

The rapidly growing concern for care and treatment of water supplies and the appeal for enforced anti-pollution measures should result in greater use of lime for water and sewage treatment. A.S.T.M. specification C 53-63 refers to the use of quicklime and hydrated lime for water treatment.

Canada is a net importer of limestone and a net exporter of lime.

OUTLOOK

The bulk of Canada's lime and limestone output is used in the construction industry and it therefore follows that trends in the construction industry govern, or at least influence, developments in the limestone, lime and cement field.

There is the possibility of increased use of lime in the metallurgical field where the basic oxygen furnace (BOF) is showing increased acceptance. In Canada over 50 per cent of steel production is now by BOF processes. Soil stabilization techniques, in which lime is used, are becoming more attractive and the use of lime as an anti-stripping agent in asphalt is becoming popular. Large quantities of lime are being used to remove SO_2 from stack gases in power generating plants in certain areas of the United States, as anti-pollution measures are being enforced. Limestone-based industries are among those most severely affected by urbanization, which provides markets and at the same time restricts mining operations. A co-operative approach to zoning regulations and land use is most necessary.

WORLD REVIEW

Public and private construction projects will continue to be the largest users of limestone and its principal products throughout the world.

Statistics covering stone and crushed stone on a world basis are not available. Tables 7 and 8 relate to world production of lime and to world production of limestone for cement manufacture.

TABLE 7

World Production of Quicklime and Hydrated Lime, Including Dead-Burned Dolomite, Sold or Used, 1966-67
(thousand short tons)

Country	1966	1967[p]
USSR[e]	19,800	19,800
United States	18,057	17,974
West Germany	11,465	11,227
Italy	5,622	5,620
Japan	2,219	3,397
France	3,208	3,009
Canada	1,573	1,422
Brazil	1,400	. .
Romania	1,154	1,157
Austria	765	751
Other countries	17,696	. .
Total	82,959	. .

Source: U.S. Bureau of Mines, Minerals Yearbook, 1967.
[p]Preliminary; . .Not available; [e]Estimated.

TABLE 8
World Production of Limestone for
Cement Manufacture
(thousand short tons)

Country	1967
USSR	125,300
United States	97,200
Japan	63,500
West Germany	46,500
Italy	38,800
France	36,300
Britain	26,000
Spain	19,400
India	17,300
Poland	16,500
China	11,800
East Germany	10,700
Canada	10,700
Czechoslovakia	9,100
Other countries	180,000
Total	709,100

Source: Calculated from World Cement Production shown in U.S. Bureau of Mines, Minerals Yearbook, 1967.

PRICES

Limestone prices vary widely and depend on the type, quality, degree of processing and the quantity of stone involved as well as the availability of the material. Refuse could bring as little as 50 cents a ton. The December 30, 1968, issue of *Oil, Paint and Drug Reporter* lists calcium carbonate, natural, dry-ground, air floated, 325 mesh, in bags, carload lots, at $13.50 to $19.00 per ton, f.o.b. plant sites in the United States.

Quicklime and hydrated lime during 1967 averaged respectively $11.36 and $13.00 per ton at the plant site in Canada.

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 lime and limestone with reductions beginning January 1, 1968. Some of the reductions made by United States are shown below.

	Jan. 1, 1968 to Dec. 31, 1968	Jan. 1, 1969
CANADA		
(Most favoured nation rates)		
Limestone not further processed than crushed and screened	free	free
Flagstone and building stone, other than marble or granite, sawn on not more than two sides	7½ per cent	7½ per cent
Lime	15 per cent	15 per cent
UNITED STATES		
Limestone, crude, broken and crushed for manufacture of fertilizer	free	free
Limestone, crude not suitable for use an monumental, paving or building steps, per short ton	18¢	16¢
Lime, hydrated and other, per 100 lb plus weight of containers	2¢	1.5¢

Staged reductions under the Kennedy Round are scheduled to lower United States tariffs to free, 10¢ and free, respectively, on and after January 1. 1972.

Sources: The Customs Tariffs and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa.
Tariff Schedules of the United States, Annotated 1969, TC Publication 272.

Lithium Minerals

W. H. JACKSON*

DOMESTIC INDUSTRY

Lithium minerals occurring in pegmatites are known at a number of localities in Canada. These were discovered in the early 1950's when there was intense world interest in the exploration and development of lithium deposits. Only one Canadian prospect achieved production, the mine of Quebec Lithium Corporation in Lacorne Township, Quebec. In the last few years competition for markets among existing world producers has intensified. This situation, coupled with the development of lithium-bearing brines in the United States, changed the economics of the market for lithium chemicals and contributed to the closure of the mine of Quebec Lithium in 1966. A prolonged strike at the mine was also a contributing factor in the closure. Residual stocks of lithium carbonate, lithium hydroxide monohydrate, chemical-grade spodumene concentrate and decrepitated spodumene concentrate were shipped from Quebec Lithium in 1967. Indicated reserves exceed 20 million tons grading 1.15 per cent Li_2O. Table 1 is a historical record of the Li_2O content of products shipped. The mine, concentrator and chemicals plant remained closed in 1968.

Production of tantalite concentrates was scheduled early in 1969 at the Bernic Lake, Manitoba property of Tantalum Mining Corporation of Canada Limited. Indicated reserves are 2 million tons grading 0.23 per cent Ta_2O_5. A 500 ton-a-day mill was under construction in 1968. Provision was made for the possible installation of a lithium circuit. Previous work on the zoned pegmatitic sill that forms the ore host rock indicated 5 million tons grading more than 2 per cent Li_2O in the form of low-iron spodumene and lepidolite, with a small amount of ambligonite. Laboratory tests have been carried out to produce low-iron spodumene and samples of the product were sent to potential customers for evaluation in 1968. The cesium mineral pollucite is found in the core zone of the sill.

A wide range of lithium products are imported into Canada but these are not detailed in import trade

TABLE 1

Production of Lithium Minerals and Chemicals in Canada*

Year	Pounds	Dollars	Year	Pounds	Dollars
1955	114,376	61,752	1962	499,736	558,654
1956	4,789,360	2,643,950	1963	644,354	682,029
1957	5,140,257	2,827,143	1964	1,056,408	1,155,282
1958	3,853,322	2,047,880	1965	1,013,565	1,141,426
1959	2,756,280	1,422,153	1966	253,566	260,611
1960	204,666	84,135	1967	436,894	266,226
1961	536,190	392,871	1968	Nil	Nil

Source: Dominion Bureau of Statistics.
*Li_2O content of lithium products shipped.

*Mineral Resources Branch.

statistics. A listing of imports includes: lithium aluminum hydride, lithium amide, lithium bromide, lithium carbonate, lithium chloride, lithium metal sealed in copper cartridges, lithium fluoride, lithium hydroxide monohydrate, lithium molybdate, lithium oxide, lithium ricinoleate and lithium stearate. Duties applicable to particular lithium compounds are not specifically elaborated in tariff schedules and require a ruling as to category.

WORLD INDUSTRY

Producers in the United States and Rhodesia are the main source of lithium ores. Operations of Bikita Minerals of Rhodesia have undoubtedly been affected by trade sanctions implemented by a number of countries at the request of the United Nations. Bikita Minerals produces petalite, spodumene and lepidolite. When consumer stocks of minerals from this source become depleted, the alternative is low-iron spodumene or production from minor deposits in other parts of the world.

In the United States there are three producers. Foote Mineral Company, Chemical and Mineral Division expanded spodumene mining capacity at Kings Mountain, North Carolina and plans to produce low-iron spodumene concentrate in 1969. The company also recovers lithium carbonate from brines at Silver Peak, Nevada, where the acreage of evaporating ponds was increased and more brine wells were drilled. Lithium Corporation of America, now merged with Gulf Resources and Chemical Corp. will be producing chemicals from its spodumene operations at Bessemer City, North Carolina in 1969. Another venture in association with Salsdetfurth A.G. of West Germany is scheduled to produce 10 million pounds of lithium salts annually from Great Salt Lake brines beginning in 1970. American Potash and Chemical Corporation, now part of Kerr-McGee Corporation recovers by-product lithium carbonate at Searles Lake, California.

For 1968, consumption of lithium products in the non-communist world, expressed in terms of Li_2CO_3 equivalent, was estimated by Foote Mineral Company at 12,325 tons. The main markets are in industrialized countries. The leading consumer is the United States with 8,250 tons followed by Europe 2,650 tons, Japan 825 tons and other countries 825 tons.

USES

Industrial applications require processing the greater part of lithium concentrates to lithium compounds except for low-iron concentrates of lepidolite, petalite and spodumene. The glass and ceramic industry consumes the low-iron concentrates directly and is also the main consumer of lithium carbonate containing a higher lithium content. Petalite is a source of lithia with a low potash, soda and iron content. Lithia forms eutectics with alkaline oxides and with silica. Resultant melts have improved fluidity and workability, less weight and there are savings in consumption of fuel and refractories in manufacturing. Glasses, glazes and enamels containing lithia have harder surfaces and glasses have a high gloss, chemical and scratch resistance, increased strength and weight reduction. Typical applications include sealed-beam headlights and various glass tubes for electronics.

Lubricating greases represent another substantial market. Lithium stearate, derived from lithium hydroxide monohydrate, combines the best characteristics of sodium and calcium soaps and permits the greases to be effective over a wide range of temperatures, from $-60^\circ F$ to $+320^\circ F$, and to be highly water resistant.

Brines of lithium chloride and lithium bromide are hygroscopic. They are used for moisture absorption in air conditioning and refrigeration. Anhydrous lithium hydroxide is an absorbent for CO_2. Research indicates that lithium carbonate, lithium chloride and lithium iodide may have potential medical applications in altering the chemical balance in the human body.

A potentially large market for lithium carbonate is in aluminum reduction cells where the experimental use of lithia as a component of the electrolyte showed improved cell efficiency.

Lithium chloride and fluoride are added to welding and brazing fluxes to remove the oxide film from aluminum and magnesium surfaces. Lithium hypochlorite is used as a bleaching agent. Butyl lithium is a catalyst in the production of synthetic rubber. Lithium hydroxide monohydrate is added to the electrolyte in nickel-iron alkaline storage batteries to increase their life and output.

Metallic lithium is too reactive to be used as a structural material. Minor quantities of lithium metal are used in the degasification of high-conductivity castings of copper and bronze. It is also used as a reducing agent in the synthesis of such pharmaceutical products as vitamins and antihistamines and as a Grignard reagent. Alloys of lithium and magnesium or aluminum have promise as light-weight metals but have yet to find markets.

PRICES

In December 1968, United States producers announced modest increases in the prices of many but not all lithium products effective January 1, 1969.

Typifying the change, the price of lithium carbonate, 99.1 per cent Li_2CO_3 in carload lots was increased from 44.5 to 46.0 cents a pound. Lithium metal, 99.9 per cent pure, in 1,000 pound lots rose 25 cents to $7.75 a pound. Lithium chloride, 99.3 per cent LiCl, was unchanged at 85 cents a pound and lithium hydroxide monohydrate, 56 per cent LiOH, was 53.5 cents in carload lots. Prices of many lithium compounds are quoted regularly in *Metals Week* and in *Oil, Paint and Drug Reporter.*

TARIFFS

Most Favoured Nation Tariff

(per cent ad valorem)

	1969*		
CANADA		UNITED STATES	
Ores of metals n.o.p.	free	Lithium ores and concentrates (crude substances)	free
Lithium compounds	subject to enquiry	Lithium compounds and salts	8
		Lithium metal	20

Source: The Customs Tariff and Amendments, Department of National Revenue; Customs and Excise Division, Ottawa; Tariff Schedules of United States Annotated (1969) TC Publication 272.
*Effective date January 1.

Magnesite

D.H. STONEHOUSE*

The mineral magnesite ($MgCO_3$) contains 47.6 per cent magnesia, and may be converted to magnesia, (MgO) by calcination. Dolomite, brucite, sea-water, sea-water bitterns and some brines may also be processed to recover magnesia. High-purity products are derived by the calcination of magnesium hydroxide or magnesium chloride resulting from treatment of these solutions.

Calcined and dead-burned magnesia are two semiprocessed products commonly used by industry. Calcined magnesia is chemically active and a product of mild calcination. Dead-burned magnesia forms during intense calcination and is chemically inactive. The mineralogical name periclase is applied in industry to dead-burned magnesia containing small amounts of iron and a minimum of 92 per cent magnesia. Other magnesium compounds such as the hydroxide, carbonate and chloride are also marketed.

The magnesia industry in Canada experienced little change other than plant improvements from 1941 to 1967. The industry perspective in Canada changed considerably in 1968 with the closure of Aluminum Company of Canada, Limited's, Wakefield, Quebec, operations and the start-up of Sea Mining Corporation Limited's magnesium hydroxide plant at Aguathuna, near Stephenville, Newfoundland. Canada's only other producer of magnesia, Canadian Refractories Limited, continued to operate its mine and kiln plant at Kilmar, Quebec, and its refractory brick plant at Marelan, Quebec.

The value of Canadian-produced dolomitic magnesite, brucite, dead-burned and calcined magnesia in 1968 was \$2.7 million, a decrease of 22 per cent from 1967. World production of crude magnesite in 1967 was estimated† to be 11.05 million tons, about the same as in 1966. Major producers in order of output are: USSR, Czechoslovakia, Austria, North Korea and Mainland China.

Canadian exports of crude refractory materials in 1968 decreased about 19 per cent by weight and 40 per cent in value from 1967. Exports of magnesite brick were down 23 per cent by weight and 20 per cent in value. Total value of imports rose by \$1.1 million, credited almost entirely to values of dead-burned magnesia and magnesite firebrick and shapes from the United States.

Recent sharp increases in consumption of magnesia products in both the pulp and paper and steel industries in Canada levelled off in 1968.

OPERATIONS IN CANADA

Aluminum Company of Canada, Limited closed its Wakefield mine and plant at the end of February 1968. The company had operated the plant since 1941 producing magnesia and lime from a brucitic limestone. The operation was closed down reportedly because of consistently poor recovery from a fairly low-grade ore. The major industries to which the

* Mineral Resources Branch.

† Source: United States Bureau of Mines Minerals Yearbook, 1967.

TABLE 1

Magnesite and Brucite – Production and Trade, 1967-68

	1967		1968p	
	Short Tons	$	Short Tons	$
Production[1], Quebec				
Dolomitic magnesite and brucite	..	3,515,917	..	2,719,377
Exports				
Crude refractory materials[2]				
United States	1,114,162	2,605,000	900,384	1,476,000
Imported[3], by United States from Canada				
Refractory magnesia including fused magnesia and dead-burned magnesia and dolomite	946	66,178	793	41,948
Magnesite brick	21,799	3,539,121	16,822	2,814,449
Imports				
Magnesia, dead-burned and sintered				
United States	31,128	2,523,000	35,701	2,912,000
Yugoslavia	4,138	275,000	5,284	370,000
Greece	2,204	167,000	1,432	108,000
Japan	772	59,000	5	...
Total	38,242	3,024,000	42,422	3,390,000
Magnesia, not elsewhere specified				
United States	2,347	189,000	3,161	340,000
Britain	1,920	249,000	15	3,000
Total	4,267	438,000	3,176	343,000
Magnesium oxide				
United States	968	367,000	1,354	422,000
Britain	26	17,000	34	16,000
Total	994	384,000	1,388	438,000
Dolomite calcined				
United States	10,436	199,000	9,906	204,000
Magnesite firebrick and other shapes				
United States	360	1,255,000	380	1,754,000
Britain	26	36,000	294	233,000
West Germany	66	68,000	41	44,000
Austria	10	20,000	34	104,000
Total	462	1,379,000	749	2,135,000

Source: Dominion Bureau of Statistics except where otherwise indicated.

[1] Includes the values of dead-burned magnesite and brucitic magnesia shipped. [2] Mainly includes materials other than magnesia. [3] Not recorded separately in the official Canadian trade statistics. The figures shown are from United States General Imports, Report FT 135, the values being in United States dollars. These materials are also exported from Canada to other countries, but the quantities and values are not available.

p Preliminary; .. Not available; ... Less than $1,000.

magnesia had been shipped were refractories, agriculture, chemicals and uranium. A description of the Wakefield operation was included in the 1967 edition of the Canadian Minerals Yearbook.

Canadian Refractories Limited, a wholly-owned subsidiary of Dresser Industries, Inc., operates a mine and beneficiation plant at Kilmar in southwestern Quebec. The company mines a magnesite-dolomite rock which is beneficiated by heavy-media separation at the plant site. The crushing, blending and heavy media separation are controlled to provide a beneficiated ore of "several required analyses" that is fed into an oil-fired rotary kiln in which the material is dead-burned to produce magnesite clinker. The clinker is crushed and sized. Some is sold to other manufacturers for refractory uses, but most of it goes to the company's modern brick plant at nearby Marelan, Quebec, for the manufacture of magnesite and chrome brick, block, ramming mixes, castables, cements and other forms of refractories. The company exports a large proportion of its products to the United States and to Europe under the trade name Magnecon. Canadian Refractories maintains a modern and active research centre at Marelan in order to keep pace with the need for refractories to withstand higher temperatures and more severe corrosion.

In 1967 Sea Mining Corporation Limited arranged for the design and construction of a plant for the recovery of magnesium hydroxide from sea-water at Aguathuna, near Stephenville, Newfoundland. Construction of a modern and impressive plant proceeded during 1968 and with start-up in September it became the first plant of this type in Canada. Sea Mining is a joint venture of Continental Ore Corporation, New York and Frederick J. Gormley Limited.

The plant has an automatically controlled acid treatment system for softening the sea-water—converting bicarbonate and carbonate ions to carbonic acid with sulphuric acid followed by the disassociation of carbonic acid into water and carbon dioxide gas. Hydrated lime, made on the site using local limestone, is reacted with the softened sea-water to precipitate magnesium hydroxide. By use of multi-stage filtration to wash and dewater the precipitate, the operator has provided a compact processing plant, which can be kept under continuous control. Foreign operations of this type, utilizing a sulphuric acid treatment system for the sea-water and multi-stage filtration of the precipitated magnesium hydroxide, have produced a high-quality magnesia containing less than one per cent lime. To date, Sea Mining has produced a magnesium hydroxide slurry only, but plans call for a calcining plant for the production of magnesia as well.

OTHER OCCURRENCES

Magnesite deposits occur in British Columbia, the Northwest Territories, Saskatchewan, Ontario, Quebec, Nova Scotia and Newfoundland. The Ontario occurrences in Deloro Township are being investigated by Canadian Magnesite Mines Limited, for whom the Mines Branch, Ottawa, has carried out extensive beneficiation tests producing a dense, 92 per cent magnesia from a magnesite concentrate. Brucite has been noted in areas of Nova Scotia, Quebec, Ontario and British Columbia. It occurs as a brucitic limestone near Rutherglen, Ontario, but no effort is currently being made to investigate this or other occurrences.

TABLE 2

Magnesite and Brucite Production*
1959-68

1959	$3,050,779
1960	3,279,021
1961	3,064,403
1962	3,431,873
1963	3,439,890
1964	3,569,619
1965	4,010,927
1966	3,948,599
1967	3,515,917
1968p	2,719,377

Source: Dominion Bureau of Statistics.

* Dead-burned magnesite and brucitic magnesia shipped. Includes small quantities of serpentine and magnesium hydroxide used or shipped.

p Preliminary.

TRADE AND CONSUMPTION

Aluminum Company of Canada, Limited supplied a "stream grade" magnesia product containing about 70 per cent MgO to Canadian Refractories Limited for dead-burning and producing refractories. With the continued need for higher-purity magnesia, an autoclaved product containing 96 per cent MgO was produced by Aluminum Company of Canada, Limited, but this product was so fine-grained that briquetting was necessary before it could be dead-burned. The high-purity magnesia powder did, however, find acceptance in the pulp and paper industries using the Magnefite process.

During the production of magnesia at Wakefield, lime (CaO) was produced in the ratio of 5 tons of lime per ton of magnesia recovered. The lime found use in the chemical industries and in uranium processing. Agricultural lime and ground limestone were supplied from the Wakefield plant and a "fertilizer grade" magnesia product containing about 60 per cent MgO was also marketed.

Canadian Refractories uses dead-burned magnesia from Kilmar in its modern brick plant at Marelan for production of Magnecon refractory products. Imported clinkers, chrome ores, and high purity magnesia are also used at this plant for the manufacture of a widely-recognized and accepted kiln liner refractory. Shipments are made to many foreign countries as well as to domestic markets.

TABLE 3

Available Data on Consumption of Magnesia in Canada, 1966-67
(short tons)

	1966	1967
Refractory brick, cements, mixes	77,071	76,901
Paper and paper products	26,437	22,940
Glass wool and fibre	6,105	6,271
Foundry	7,165	4,757
Other*	1,401	1,749
Total	118,179	112,618

*Includes: fertilizers, rubber production, ferrosilicon, sugar processing, etc.

Sea Mining has indicated that its markets will be in both the refractory field and pulp and paper field. The company's plant is well situated to ship product to St. Lawrence and Great Lakes ports, to the eastern seaboard of the United States and to overseas countries. Its first shipment of magnesium hydroxide in slurry form, reportedly went to United States in late 1968.

Recorded consumption of magnesia in Canada during 1967 was 5 per cent lower than that for 1966, refractory uses accounting for 69 per cent of the total. High-magnesia refractories are produced at the following plants in Canada: Canadian Refractories Limited, Marelan, Quebec; General Refractories Company of Canada Limited, Smithville, Ontario; Refractories Engineering and Supplies Limited, Bronte, Ontario; Norton Company, Chippawa, Ontario; and, as of July 1968, Kaiser Refractories Company, Division of Kaiser Aluminum & Chemical Canada Limited, Oakville, Ontario. Except for the first-mentioned operation, all plants are dependent upon imported magnesia; Kaiser Refractories Division brings dead-burned magnesia from the company's sea-water magnesia plant at Moss Landing, California. Dead-burned dolomite is produced by Steetley of Canada Limited at Dundas, Ontario, for use by the steel industry.

WORLD REVIEW

Although statistics relating to magnesite production are difficult to obtain, estimates* of output on a world wide basis put the USSR well in the lead with Czechoslovakia running a closer second each year. Austria ranks third and is reported to be the leading exporter of magnesite. The need for greater than 98 per cent MgO in refractories to contain the greater heats being attained in the steel industries has resulted in the development of new deposits, new methods of beneficiating and new calcining techniques. In the United States nearly all the magnesia used to produce high-quality refractories is recovered from sea-water or from lake brines. This product is available for export to Canada and provides strong competition to Canadian-produced dead-burned magnesite.

OUTLOOK

With the trend to high-purity magnesia for refractory products, establishment of sea-water magnesia plants is favoured over the development of new magnesite orebodies or the development of better beneficiation techniques for up-grading natural magnesite. There is little likelihood that consumers of magnesia will cease their practice of setting very exacting specifications for the material they purchase nor that producers will be free of the responsibility of providing many grades of product. Plant location near main consuming industries and the ability to maintain production of high-quality, uniform magnesia product are of major importance to the industry.

* U.S. Bureau of Mines, Minerals Yearbook, 1967.

PRICES

According to *Oil and Paint Drug Reporter* of December 30, 1968, United States prices were as follows:

Magnesite, dead-burnt, standard grain, bulk, car lots, f.o.b., Chewela, Washington	per ton	$46.00
Magnesia, calcined, technical, heavy, 90%, bags, car lots, f.o.b., Lunning, Nevada	per ton	$53.00
93% same basis	per ton	$56.00
95% " "	per ton	$61.00
Magnesite, chemical grade, calcined, powdered, bags, car lots, f.o.b. works	per ton	$88.75

TARIFFS

	British Preferential	Most Favoured Nation	General
CANADA			
Magnesite, crude rock	free	free	free
Magnesite, dead-burned or sintered; magnesite, caustic calcined; plastic magnesia	15%	15%	30%

UNITED STATES

Magnesite, crude	
Jan. 1, 1968 to Dec. 31, 1968	$4.72 per long ton
Jan. 1, 1969 to Dec. 31, 1969	4.20 per long ton
Magnesite, caustic calcined	
Jan. 1, 1968 to Dec. 31, 1968	9.45 per long ton
Jan. 1, 1969 to Dec. 31, 1969	8.40 per song ton
Magnesite bricks	
Jan. 1, 1968 to Dec. 31, 1968	0.34¢ per pound + 4.5%
Jan. 1, 1969 to Dec. 31, 1969	0.30¢ per pound + 4%

Reductions under the Kennedy Round of the General Agreement on Tariffs and Trade (GATT) that was convened in 1964 and concluded in 1967, will lower United States tariffs to $2.62 and $5.25 per long ton and 0.19¢ per pound +2.5% respectively, on and after Jan. 1, 1972.

Sources: The Customs Tariffs and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa.
Tariff Schedules of the United States, Annotated (1969)
TC Publication 272

Magnesium

W.H. JACKSON*

There are two basic methods of producing magnesium: high temperature reduction of calcined dolomite with ferrosilicon under vacuum, and electrolysis of anhydrous magnesium chloride. Relatively few countries produce primary magnesium. Plant capacities by country, company and type are shown in the table, World Primary Magnesium Capacity 1968. Demand for magnesium continues to grow and has overtaken available supply. The result has been a firming price trend as marginal supplies dwindled, and the initiation of new smelter construction in a number of countries.

CANADIAN INDUSTRY

Primary magnesium is produced in Canada by Dominion Magnesium Limited. The company has operated its mine and smelter at Haley, Ontario, since 1942. Dolomite, low in impurities such as silica and the alkali metals, is mined by open pit and calcined in a rotary kiln to produce dolime. Magnesium is recovered by the Pidgeon process wherein the dolime is mixed with ferrosilicon and some fluorite and charged in batches into retorts that are externally heated in electric furnaces. Under vacuum and at high temperature, the magnesium content is reduced and accumulates as crystalline rings called 'crowns' in the water-cooled head-sections of the retorts. The plant, which is a major source of employment in the Renfrew area, has 544 retorts in 16 furnaces and a magnesium production capacity of 11,300 tons a year. All furnace capacity was in operation in 1968; part of it was utilized for the production of calcium.

The company produces magnesium 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.

For Commercial-grade magnesium, the crowns are remelted and cast into ingot forms. This grade is suitable for general fabrication purposes and for alloying with aluminum. The High Purity grade does not represent significant tonnages and is mainly used to make Grignard reagents. The Refined grade is particularly suited for chemical laboratory use, and as a reducing agent for uranium, zirconium, titanium and beryllium or similar applications where impurity control is important.

Production data in Table 1, provided by the Dominion Bureau of Statistics, differs from the annual report of the company that lists production of magnesium crowns in 1968 at 11,143 tons and metal shipments at 11,100 tons. Shipments in 1968 compare favourably with the 9,777 tons shipped in 1967. At capacity, over 70 per cent of the output must be exported as the Canadian ingot market is shared with other suppliers.

The growth of the Canadian market is illustrated by Table 2, Canada, Magnesium Consumption 1960 and 1967-68. For 1968, the market for primary magnesium and alloys was estimated at 5,700 tons. More magnesium is used as an additive in aluminum alloys than in any other application, approximately 65 per cent of the total. Extrusions and die-castings are other areas of growth since 1960.

*Mineral Resources Branch.

TABLE 1

Canada, Magnesium Production and Trade, 1967-68

	1967		1968p	
	Short Tons	$	Short Tons	$
Production (metal)	8,887	5,653,243	9,878	6,153,270
Imports				
Magnesium metal				
United States	1,430	1,105,000	1,295	1,013,000
West Germany	–	–	558	296,000
USSR	2	1,000	550	293,000
Britain	57	38,000	–	–
Austria	4	5,000	–	–
Total	1,493	1,149,000	2,403	1,602,000
Magnesium alloys				
United States	189	777,000	301	1,568,000
Britain	17	26,000	1	4,000
Total	206	803,000	302	1,572,000
Exports				
Magnesium metal				
United States	..	1,526,000	..	1,978,000
Britain	..	1,371,000	..	1,684,000
France	..	282,000	..	329,000
Mexico	..	26,000	..	122,000
Argentina	..	1,000	..	61,000
Switzerland	..	39,000	..	31,000
Other countries	..	451,000	..	56,000
Total	..	3,696,000	..	4,261,000

Source: Dominion Bureau of Statistics.
p Preliminary; .. Not available.

Imports of metal and alloys, 2,705 tons in 1968, account for some 43 per cent of the Canadian market. Imports of wrought magnesium are not included. Such items are mainly mill forms of sheet from the United States and imports from this source amounted to 435 tons valued at $842,557 (US).

The main Canadian export markets continue to be United States and Britain with lesser amounts shipped to a number of countries. Canadian foreign trade statistics, which record only the dollar value of magnesium exports, indicate that the United States is the main market. Imports from Canada into the United States reported by the U.S. Department of Commerce, included 2,785 tons of magnesium metal or alloys and 1,038 tons of scrap for 1968. Exports of magnesium metal to the United States from Canada are possible through the Canada-United States Defence Production Sharing Act. Scrap enters the United States free of duty. Tariff changes resulting from the Kennedy Round of trade negotiations under the General Agreements on Tariffs and Trade have not greatly changed the outlook for the sale of magnesium to the United States or Western Europe. The ultimate U.S. tariff will be 20 per cent in 1972; the comparable Canadian tariff will be 5 per cent.

WORLD INDUSTRY

The main national markets for magnesium are the United States, West Germany, Britain, Japan, France, Italy and Canada. Consumption data in the non-communist world are incomplete for magnesium but consumption approximates production, plus sales from the United States stockpile, plus occasional imports from communist countries. Primary production in the non-communist world was estimated at 161,000 tons for 1968. Primary capacity is likely to increase from 169,000 tons at the end of 1968 to some 360,000 tons by 1971-72 assuming that announced expansion plans are completed. Secondary mangesium adds to effective supply in a number of countries. Incomplete data for 1967 give the order of magnitude of secondary production as follows: Britain 4,400 tons, West Germany 2,400, Japan 7,900, and United States 17,600 tons.

Growth in magnesium markets has resulted in expansion plans by a number of primary producers or potential producers. The main expansion is in the United States where new sources of magnesium chloride are being developed and where an advance in electrolytic smelting technology offers the possibility of magnesium production at substantially lower cost. The new electrolytic plants will produce both magnesium and chlorine, requiring a market for both products. Capital costs for new electrolytic capacity in the United States are about $850 (US) a ton of annual capacity exclusive of raw material facilities.

The smelters of The Dow Chemical Company at Freeport, Texas, currently produce over 90 per cent of United States output. Expansion by some 25,000 tons was deferred until mid-1969 to incorporate new technology. When plant additions are completed, Freeport will have an annual magnesium capacity of 125,000 tons. By late 1971, Dow also plans to construct a new 25,000-ton electrolytic smelter at Downsville, Washington and possibly double that by 1974. The new facility will be based on brines from the Great Salt Lake in Utah where a plant will be constructed to produce anhydrous magnesium chloride. Raw magnesium chloride will be purchased from an adjacent plant of Great Salt Lake Minerals & Chemical Corp. The latter is constructing a plant capable of producing annually 5,000 tons of lithium chloride, 300,000 tons of magnesium chloride, 200 tons of potassium sulphate, 100,000 tons of sodium sulphate, and 2,500 tons of bromine, from Great Salt Lake brines. Another magnesium smelter project based on Great Salt Lake brines is that of the Magnesium Division, National Lead Company. Subject to completion of financing, construction of the 45,000-ton annual-capacity plant should start in 1969 with initial production in 1971, probably at 15,000 tons.

TABLE 2

Canada, Magnesium Consumption,
1960 and 1967-68
(short tons)

	1960	1967	1968p
Consumption (metal)			
Castings	158	631	593
Extrusions[1]	230	571	..
Aluminum alloys	1,339	3,253	..
All other products[2]	472	599	..
	2,199	5,054	5,700e

Source: Dominion Bureau of Statistics.
[1]Includes a small amount of other wrought products.
[2]Includes magnesium used as a reducing agent for cathodic protection and in other alloys.
p Preliminary; .. Not available for publication;
e Estimated.

TABLE 3

Canada, Magnesium Production, Trade and
Consumption, 1959-68

	Production	Imports		Exports	Consumption
	Metal (short tons)	Alloys (short tons)	Metal (short tons)	Metal $	Metal (short tons)
1959	6,102	..	..	3,879,588	1,668
1960	7,289	..	..	3,232,805	2,199
1961	7,635	..	..	3,608,523	2,776
1962	8,816	..	..	3,967,932	3,614
1963	8,905	..	..	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	4,473
1966	6,723	330	3,011	3,452,000	5,187
1967	8,887	206	1,493	3,696,000	5,054
1968p	9,878	302	2,403	4,261,000	5,700e

Source: Dominion Bureau of Statistics.
p Preliminary; .. Not available; e Estimated.

TABLE 4

World Primary Magnesium Production, 1960 and 1967-68
(thousand short tons)

	1960	1967	1968^{e}
United States	40.0	97.2	98.4
USSR	27.0	39.0	39.0
Norway	14.3	33.6	34.5
Canada	7.3	8.9	9.8
Italy	5.9	6.9	7.3
Britain	1.7	Nil	Nil
Japan	2.3	7.4	6.2
France	2.3	4.6	4.9
China	1.1	1.0	1.0
Poland	0.2	0.3	0.3
West Germany	0.3	Nil	Nil
Total	102.4	198.9	201.4

Source: American Bureau of Metal Statistics, and Metallgesellschaft A.G.

^{e} Estimated.

TABLE 5

Estimated World Primary Magnesium Capacity, 1968

	Annual Capacity (short tons)
CANADA	
Dominion Magnesium Limited	11,300 (F)
FRANCE	
Pechiney-Ugine, Magnesium Thermique	6,300 (F)
Planet-Wattohm S.A.	1,000 (F)
ITALY	
Societe Italiana per il Magnesio e Leghe di Magnesio, S.P.A.	7,000 (F)
JAPAN	
Furukawa Magnesium Company	6,600 (F)
Ube Kosan KK	3,000 (F)
NORWAY	
Norsk Hydro-Elektrisk	40,000 (E)
UNITED STATES	
Alamet Division of Calumet & Hecla, Inc.	9,200 (F)
The Dow Chemical Company	95,000 (E)
Titanium Metals Corporation	12,000 (E)
USSR	50,000 (E)

Process: F Ferrosilicon; E Electrolytic.

American Magnesium Company started construction in March 1968 on a 30,000-ton electrolytic plant at Snyder, Texas that should be in partial (10,000 tons) operation by mid-1969. Local brines containing 11 per cent magnesium chloride are the raw-material base. Oregon Metallurgical Corp. plans to build a 10,000 ton magnesium smelter at Albany, Oregon from which the magnesium will be used in titanium metal production. Startup is expected in 1970.

In summary, United States capacity by 1971-72 could reach 244,000 tons. Unless one or more companies stretch out the period in which full capacity is achieved, there is a distinct possibility that the full capacity will not be utilized immediately. However, all companies have a captive base upon which to build markets.

United States production in 1968 was 98,375 tons, and shipments were 103,446 tons. In the same year imports of ingot, alloys and scrap were 4,791 tons and exports were 18,364 tons. There was a tight supply situation in 1968 and a shortage might have developed if releases from the government stockpile had not been authorized. In October, 1968 the General Services Administration was authorized to sell 55,000 tons. Some of the metal has already been sold at 32 cents a pound and the remainder will be offered from time to time. When sales are complete, there will be no magnesium in the United States stockpile in excess of the 90,000-ton objective for the needs of conventional warfare. As of December 31, 1968 the United States magnesium stockpile contained 54,195 tons in excess of its objective. The total United States market was in the order of 117,000 tons in 1968. The consumption pattern in tons was as follows: castings, 18,000; mill products 18,000; anodes etc., 9,000; ductile iron 6,000; reducing agent 8,000; powder 12,000; and aluminum alloys 46,000.

For the rest of the world, announced expansion plans represent much smaller increments to capacity. In Italy, Compagnia Generale del Magnesio is planning a $12.5 million smelter (probably 13,000 tons) near Syracuse, Italy to meet the needs of the Fiat organization and to export to the European Economic Community. The main French producer plans to increase capacity to 7,700 tons. West Germany is the second largest market after the United States, and a joint venture between the Norwegian producer and Salzdetfurth A.G. of Hanover, Germany is an important development.

Japanese output of primary magnesium is mainly consumed in the production of titanium. Secondary magnesium is recovered by two companies, Toho Titanium Company Limited and Osaka Titanium Company Limited.

USES

The main market for magnesium, and a steadily expanding one, is for alloying with aluminum. Its use as a reducing agent should also increase because of greater demands as uranium and titanium production each increase. Sacrificial anodes for corrosion protection represent a useful market as does the demand for Grignard reagents, an intermediate step in the manufacture of tetra ethyl or methyl lead compounds. Incendiary devices are another application.

As a structural material, an extensive technology has been developed to utilize the properties of magnesium alloys and mill forms. Industry has been gradually accepting magnesium for its intrinsic properties of strength, lightness and rigidity. For many applications both zinc and aluminum are firmly established and market penetration by magnesium for those applications has been difficult except where finished products show a distinct advantage in cost or performance. Extrusions and rolled products of magnesium are available for a wide variety of applications. Die-castings are likely to show the best growth rate as new alloys have recently been developed. Also, an increase in the number and size of producers will improve the supply base and should cause manufacturers to re-assess the possibilities of magnesium in the design and engineering of products, particularly for the automotive market.

PRICES

The domestic quotation in Canada for Commercial-grade magnesium remained unchanged at 31 cents a pound, f.o.b. Haley throughout 1968. Prices were increased to 32 cents on January 1, 1969 and to 33 cents on May 15, 1969. In the United States, the competitive selling price was between 32 and 33 cents in 1968.

TARIFFS

Most Favoured Nation Tariff
(per cent ad valorem)

	1969*
CANADA	
Magnesium metal	14%
Magnesium alloys	8%
Magnesium scrap	free
UNITED STATES	
Magnesium metal, unwrought	32%
Magnesium alloys, unwrought	12.8¢ + 6%
Magnesium scrap	free

Source: The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa; Tariff Schedules of the United States Annotated (1969), TC Publication 272.

*Effective date January 1.

Manganese

G.P. WIGLE*

Canada imported 69,209 tons of manganese contained in ores and concentrates in 1968 valued at $3.9 million compared with 82,659 tons valued at $5.2 million in 1967. Imports of ferromanganese, silicomanganese and spiegeleisen totalled 29,285 tons valued at $3.8 million compared with 20,246 tons valued at $3.4 million in 1967.

Ores of manganese are not produced in Canada but small amounts have been mined intermittently from occurrences in Nova Scotia, New Brunswick and British Columbia. Low-grade occurrences in the Atlantic Provinces have been examined but are of no present economic importance. The large low-grade deposit near Woodstock, New Brunswick, is reported to contain 50 million tons grading 11 per cent manganese and 14 per cent iron.

WORLD PRODUCTION AND TRADE

Estimated world production of manganese ores was 18.7 million tons in 1968, approximately the same as in 1967. Russia is the largest producer with an estimated output of 7.9 million tons in 1967. Brazil, Gabon, India and the Republic of South Africa each produced from 1.2 to 2.0 million tons in 1968, about the same as in 1967.

The principal sources of Canada's imports of manganese ores were Ghana, Republic of the Congo (Kinshasa), and Brazil; some five other countries, as outlined in Table 1, supplied the remainder. The principal supplier of imported ferromanganese was again the Republic of South Africa.

The United States is the leading importer and consumer of manganese ores. The U.S. Department of the Interior, Bureau of Mines, Mineral Industry Surveys reported imports of 1.8 million tons and consumption of 2.2 million tons in 1968. The leading suppliers were Brazil, Gabon, Republic of South Africa, Republic of the Congo (Kinshasa), India, Angola and Australia. Australian production of manganese ores in 1967 was over 600,000 tons compared with 350,000 tons in 1966. United States imports of ferromanganese were 214,125 tons compared with 209,673 tons in 1967. United States' consumption of ferromanganese was 959,533 tons in 1968.

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 the ability to work-harden to a high degree. 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 in 1968 was 94 per cent metallurgical, 5 per cent chemical and miscellaneous, and 1 per cent in the dry-cell battery industry. In Canada, 98.45 per cent of consumption was metallurgical grade ore, nearly all used in the steel industry and 1.55 per cent was battery and chemical grade.

* Mineral Resources Branch.

The principal form in which manganese is used by the steel industry is as ferromanganese; the most important of the ferroalloys used in steelmaking. The gross weight of ferromanganese used in Canada in 1967 was 61,667 tons, silicomanganese used was an additional 18,910 tons while consumption of two other important ferroalloys, ferrosilicon and ferrochrome was 34,807 tons and 19,557 tons respectively.

TABLE 1

Canada, Manganese Trade and Consumption, 1967-68

	1967		1968p	
	Short Tons	$	Short Tons	$
Imports				
Manganese, in ores and concentrates[1]				
Ghana	20,829	1,335,000	16,306	766,000
Congo-Kinshasa	13,612	817,000	11,827	496,000
Brazil	11,622	634,000	11,239	561,000
French Africa	–	–	9,712	604,000
India	4,666	180,000	5,663	354,000
USSR	5,395	370,000	5,092	261,000
United States	6,097	829,000	4,979	717,000
Republic of South Africa	11,117	504,000	4,298	160,000
Other countries	9,321	531,000	93	23,000
Total	82,659	5,200,000	69,209	3,942,000
Ferromanganese including spiegeleisen[2]				
Republic of South Africa	13,837	1,868,000	26,508	3,390,000
United States	2,036	545,000	1,215	233,000
Norway	–	–	100	19,000
Japan	123	35,000	78	22,000
France	48	22,000	40	18,000
Total	16,044	2,470,000	27,941	3,682,000
Silicomanganese, including silico spiegeleisen[2]				
Yugoslavia	–	–	560	56,000
USSR	564	64,000	547	61,000
United States	2,296	666,000	199	32,000
Norway	–	–	38	11,000
Republic of South Africa	1,342	198,000	–	–
Total	4,202	928,000	1,344	160,000
Exports				
Ferromanganese[2]				
United States	4,334	1,729,000	963	116,000
Sweden	–	–	55	6,000
Colombia	5	1,000	–	–
Total	4,339	1,730,000	1,018	122,000
Consumption[2]				
Manganese ore				
Metallurgical grade	135,715		122,966	
Battery and chemical grade	1,680		1,938	
Total	137,395		124,904	

Source: Dominion Bureau of Statistics.
[1]Mn content. [2]Gross weight.
[p]Preliminary; – Nil.

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 it is available in several grades containing 0.75 per cent or less carbon and 80 to 85 per cent manganese.

The consumption of manganese additive materials in the United States in 1968 is outlined in Table 5.

TABLE 2

Canadian Manganese Imports, Exports and Consumption, 1958-68
(gross weight, short tons)

	Imports			Exports	Consumption	
		Ferromanganese				
	Manganese Ore[1]	Under 1% Silicon	Over 1% Silicon	Ferro-manganese	Ore	Ferro-manganese
1959	118,454	2,334	2,989	193	90,311	40,976
1960	56,350	15,495	2,366	729	73,019	40,177
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[p]	69,209	27,941	1,344	1,018	124,904	. .

Source: Dominion Bureau of Statistics.
[1]From 1964, Mn content.
[p]Preliminary; . . Not available.

TABLE 3

World Production of Manganese Ore, 1966-68
(short tons)

	1966	1967	1968[e]
USSR	7,720,000[e]	7,940,000[e]	. .
Republic of South Africa	1,866,166	1,930,000[e]	2,000,000
India	1,849,550[r]	1,762,594	1,700,000
Gabon	1,403,814	1,264,350	1,200,000
Brazil	1,603,745[r]	1,248,000	1,200,000
China, Mainland	1,102,000[e]	770,000[e]	. .
Ghana	647,422	580,000[e]	. .
Republic of the Congo (Kinshasa)	274,809	307,813	. .
Morocco	399,499	315,413	. .
Japan	353,733[r]	374,963	. .
Australia	303,470[r]	600,000[e]	. .
Other countries	1,616,792	1,556,867	12,600,000[1]
Total	19,141,000[r]	18,650,000	18,700,000

Source: For 1966 and 1967, U.S. Bureau of Mines, Minerals Yearbook 1967.
1968 U.S. Bureau of Mines, Commodity Data Summaries, January 1969.
[1]Includes estimate for unavailable figures.
[p]Preliminary; . . Not available; [r]Revised; [e]Estimated.

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 "	1.50 "
low-carbon	80-85	7.00 "	.75 "
Silicomanganese	65-68	18-20	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
Manganese Ferroalloys and Metal, 1968
(short tons, gross weight)

Ferromanganese:	
High carbon	852,641 tons
Medium and low carbon	106,892 tons
Silicomanganese	150,846 tons
Spiegeleisen	23,140 tons
Manganese metal	21,038 tons

Source: Mineral Industry Surveys, U.S. Department of the Interior, Bureau of Mines, Washington, D.C.

MINERALS AND SOURCES

Manganese occurs in a great 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 ($MnO_2H_2O.K,Na,Ba$ 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 due to decomposition and reconcentration.

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.

Russia is the largest producer and is the only major industrial nation that is self-sufficient in manganese production and has very large reserves. Important manganese deposits are found in the Republic of South Africa, India, Brazil, Gabon, Ghana, Guyana and Mainland China. Australia has become a major producer in very recent years. Many other countries contribute to world production.

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 any particular ore is seldom of 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 1967 and used in producing ferromanganese, silicomanganese and manganese metal varied in grade from 36.1 per cent to 50.5 per cent manganese and averaged 45.4 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, usually 68 per cent or more. Ores that are suitable for the manufacture of dry-cell batteries are usually suitable for metallurgical use but metallurgical

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)	48.98	2.39	7.07	4.46	0.125	..	..
"	49.67	2.38	5.90	5.75	0.114	..	..
"	50.54	2.37	4.56	4.50	0.142	..	..
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
USSR (Chiatura)[4]	53	1.2	..	2.0	0.17	7.5	44.2
USSR (Nikopol)[5]	49	1.5	..	1.4	0.20	12.0	32.7

Source: Compiled from a survey of technical and trade publications.

Note: [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.

ores are less frequently suitable for batteries. There is no quick analytical procedure to determine suitability for battery manufacture. Tests are carried out by making batteries from trial lots of ore and placing the batteries in test service.

CHEMICAL-GRADE MANGANESE ORE

Chemical-grade manganese ore should contain not less than 35 per cent manganese. It is used to make various manganese chemicals including 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.

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. Chromium Mining & Smelting Corporation, Limited produces manganese alloys at its plant in Beauharnois, Quebec. Imported electrolytic manganese is used by Atlas Steels 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 Algoma 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 of Canada Limited, both of Toronto; and Ray-O-Vac (Canada) Limited, Winnipeg.

PRICES

Manganese ore of good quality was in plentiful supply and prices declined during 1968. Good grade ore was reported to have been delivered at eastern United States' ports in large tonnages for less than 60 cents per long ton unit of manganese. *Metal Bulletin* (46 Wigmore St., London) in their December 31, 1968 publication gave the following range of prices:

Manganese, metallurgical, per long ton unit of Mn:	
48/50% Mn grade, max. 0.1% P, CIF	54d.-59d.
46/48% grade CIF	52d.-58d.
38/40% grade CIF	nominal
Manganese, battery grade, per long ton:	
70/85% MnO_2, lump, CIF	£26 - £29
70/75% MnO_2, ground, blended, CIF	£40 - £45
Ferromanganese, *Metals Week* issue of December 30, 1968, f.o.b. shipping point, freight equalized to nearest main producer, carload lots, lump, bulk per long ton:	
Standard, 74-76% Mn	U.S. $164.50 (nominal)
78-82%	170.00 (nominal)
low-phosphorus	180.00 (nominal)
Manganese metal, electrolytic, 99.9%, per pound Mn, f.o.b. shipping point:	
Regular	26.6¢ U.S.
Hydrogen-removed	26.6¢ U.S.
4-5% N	28.6¢
6% N	30.6¢

TARIFFS

Item No.		Most Favoured Nation January 1, 1968	Most Favoured Nation January 1, 1969
CANADA			
32900-1	Ores of metals, not otherwise provided for (manganese ore)	free	free
35104-1	Electrolytic manganese	5%	free
37501-1	Ferromanganese and spiegeleisen not more than 1% Si content, on the Mn content per pound	0.9¢	0.8¢
37502-1	Silicomanganese, more than 1% Si content, on the Mn content per pound	1.35¢	1.20¢
UNITED STATES			
601.27	Manganese ore, on Mn content per pound (duty temporarily suspended)	0.22¢	0.2¢
632.32	Manganese metal, unwrought, waste and scrap (duty on waste and scrap temporarily suspended)	1.8¢/lb+ 15%	1.7¢/lb+ 13%
607.35	Ferromanganese, not over 1% C, on Mn content	0.5¢/lb+ 4%	0.4¢/lb+ 3.5%
607.36	Ferromanganese, over 1% C but not over 4% C on Mn content	0.8¢/lb	0.7¢/lb
607.37	Ferromanganese, over 4% C, on Mn content	0.55¢/lb	0.5¢/lb

Sources: The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa. Tariff Schedules of the United States Annotated (1969), TC Publication 272.

Mercury

J. G. GEORGE*

With the reactivation of the Pinchi Lake mine in 1968 by Cominco Ltd., Canada again became a substantial producer of mercury. With the exception of small quantities produced in 1955, 1964 and 1965 in the Bridge River district in southern British Columbia, there had been no mine production of mercury in Canada since 1944 when the Pinchi Lake and Takla mines, both in British Columbia, were closed. The Pinchi Lake and Takla properties were operated as underground mines during World War II by Cominco Ltd. and Bralorne Pioneer Mines Limited, respectively.

The Pinchi Lake mine, located some 30 miles north of Fort St. James, British Columbia, was Canada's sole mine producer of mercury in 1968. It restarted operations in August, with the concentrator processing about 700 short tons of cinnabar ore a day. The concentrate is roasted at the mine site to produce refined mercury metal.

Silverquick Development Co. (B.C.) Ltd. reported late in 1968 that it was constructing a 500-ton-a-day concentrator at its mercury property near Goldbridge in the Bridge River district of southern British Columbia. The company's mine, mill and roasting facilities were scheduled to begin operations in July 1969, with an annual production goal reported to be 3,000 flasks (76 pounds each) of mercury. Proven ore reserves have been estimated at 400,000 tons grading 0.1 per cent mercury and indicated reserves at 1,000,000 tons of the same grade. All of these reserves are in the No. 1 open-pit area. Exploration and underground development work was done by Empire Mercury Corporation Ltd. on its mercury property in the Bridge River district. Probable ore reserves were reported to be 700,000 tons grading 1.1 pounds of mercury per ton. Highland Mercury Mines Limited planned to do further development work on its mercury prospect near Cominco's Pinchi Lake mine; no work was done in 1968. Several other companies explored mercury prospects in the Pinchi Lake area, the Kamloops Lake area, and the Bridge River district, all in British Columbia.

Canadian imports of mercury in 1968, at 197,900 pounds, represent a reduction to almost one half those of 1967. Statistics on Canadian production and exports of mercury are not available. Reported consumption in Canada in 1967 was 245,121 pounds. Consumption figures for 1968 are not available.

WORLD REVIEW

In 1968, Spain and Italy together produced more than 40 per cent of the estimated world mine output of 261,000 flasks of mercury. The seven largest producing countries, in declining order of output, were Spain, Italy, Russia, United States, Mainland China, Mexico and Yugoslavia; their combined output accounted for over 90 per cent of world mine production of mercury.

Mine output of mercury in the United States declined steadily from 33,223 flasks in 1960 to 14,142 flasks in 1964, but this trend was reversed in 1965 when production rose to 19,582 flasks. Since then the output has risen continually. The United States is believed to be the world's largest consumer of mercury but has always produced less than its requirements. United States consumption in 1968 was estimated at 75,422 flasks. Accurate statistics are not available on consumption in other foreign countries but Britain, France, Japan, Russia, West Germany and others are reported to be consuming greater quantities of mercury. The substantial increases in world consumption of mercury in recent years are largely due to

*Mineral Resources Branch.

TABLE 1

Canadian Mercury Production, Trade and Consumption, 1967-68

	1967		1968P	
	Pounds	$	Pounds	$
Production	–	–	..	..
Imports				
Yugoslavia	11,400	33,000	69,800	521,000
United States	48,300	312,000	59,400	447,000
Spain	121,600	827,000	30,400	224,000
Mexico	125,800	868,000	22,300	168,000
Belgium and Luxembourg	–	–	11,400	81,000
Peru	200	1,000	4,600	36,000
Netherlands	33,800	243,000	–	–
Philippines	8,000	57,000	–	–
Mainland China	4,600	30,000	–	–
Italy	2,600	15,000	–	–
Total	356,300	2,386,000	197,900	1,477,000
Consumption, metal				
Heavy chemicals	160,842		..	
Electrical apparatus	27,848		..	
Gold recovery	1,697		..	
Miscellaneous	54,734		..	
Total	245,121		..	

Source: Dominion Bureau of Statistics
P Preliminary; – Nil; .. Not available.

TABLE 2

Canadian Mercury Production, Trade and Consumption, 1959-68

	Production Metal (Pounds)	Imports		Exports Metal (Pounds)	Consumption Metal (Pounds)
		Metal (Pounds)	Salts ($)		
1959	–	141,219	6.137	10,458	161,987
1960	–	243,091	6,915	1,918	139,627
1961	–	312,913	3,764	..	150,588
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
1968P	..	197,900	..	..	..

Source: Dominion Bureau of Statistics.
P Preliminary; – Nil; .. Not available.

world-wide expansion of the production of chlorine and caustic soda, and to the rapid growth of the electrical industry. Mercury is used as a cathode in the electrolytic preparation of chlorine and caustic soda. Mercury cells are, however, becoming more efficient and, in future, the rate of growth for this outlet will probably be somewhat lower as per-cell needs decline.

Demand for mercury was strong as 1968 began, and a shortage developed. Spain was reportedly out of the market, although it was still filling prior commitments, and severe winter weather conditions hampered output in the United States. During the remainder of the year, however, the tight supply situation was eased by a tapering off in demand and by substantial sales, by the General Services Administration (GSA), of excess mercury previously held by the United States Atomic Energy Commission (AEC). Supplies were further increased late in the year with the inception of sales by Cominco Ltd. from its Pinchi Lake mine.

TABLE 3

World Production of Mercury
(flasks of 76 pounds)

	1964	1967p	1968p
Spain	78,322	50,000	57,262
Italy	57,001	48,066	52,215
Russia[e]	35,000	45,000	45,000
United States	14,142	23,784	28,874
Mainland China[e]	26,000	20,000	20,000
Mexico	12,561	23,874	17,195
Yugoslavia	17,318	15,890	15,558[e]
Turkey	2,615	3,500[e]	6,500[e]
Japan	4,812	4,612	5,047
Canada	73	–	5,000[e]
Philippines	2,496	2,612	3,506
Peru	3,275	2,980	3,125
Czechoslovakia[e]	775	900	900
Chile	267	184	513
Tunisia	87	250	300[e]
Colombia	3	100	285
Romania	194	190	203[e]
Bolivia (exports)	32	100	134
Total	254,973	242,042	261,000[e]

Sources: Minerals Yearbook 1967, United States Department of the Interior, for 1964 and 1967 figures. Mineral Industry Surveys, United States Department of the Interior, Mercury in the First Quarter of 1969, for 1968 statistics.
p Preliminary; e Estimated; – Nil.

At the end of 1968, United States government stockpiles contained a total of 200,266 flasks of mercury; the stockpile objective being 200,000 flasks. These stocks are exclusive of excess mercury held by AEC. In January 1965, 55,500 flasks of surplus AEC stocks were made available for sale to United States domestic consumers, and an additional 20,000 flasks were released late in 1966. Of the total 75,500 flasks authorized for sale, some 73,200 flasks had been sold to the end of 1968 leaving only about 2,300 flasks for sale early in 1969.

USES

One of the oldest but now relatively unimportant uses of mercury is for recovering gold and silver from their ores by amalgamation. The two major uses in recent years have been for electrical apparatus and for the electrolytic production of chlorine and caustic soda. Together they accounted for almost 50 per cent of mercury consumed in the United States in 1968. Electrical uses include mercury lamps, batteries, rectifier bulbs, oscillators, and various kinds of switches including "silent" switches for use in the home. Mercury lamps are adaptable to higher-voltage supply lines than those used with incandescent lamps and, for this reason, 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.

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. Mercury's military uses include fulminate for munitions and blasting caps, and as a catalyst in the manufacture of chemicals for chemical warfare. 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.

PRICES

The price of mercury per flask (76 pounds) f.o.b. New York, as quoted in *Metals Week*, rose from $520 at the beginning of 1968 to a high of $605 in mid-February. Thereafter, the New York price continually declined to a low of $500 early in July. During the rest of the year it fluctuated between $500 and $555. Average for the year was $535.55 a flask, compared with an average of $489.35 for 1967. The

TABLE 4

United States Mercury Consumption, by Uses
(flasks of 76 pounds)

Use	1964	1967	1968P
Agriculture (includes fungicides and bactericides for industrial purposes)	3,144	3,732	3,430
Amalgamation	308	219	267
Catalysts	656	2,489	1,914
Dental preparations	2,612	1,359	2,089
Electrical apparatus	10,690	13,823	19,439
Electrolytic preparation of chlorine and caustic soda	9,572	14,306	17,453
General laboratory use	17,329*	1,133	1,246
Industrial and control instruments	4,972	3,865	3,935
Paint			
antifouling	547	152	392
mildew-proofing	4,898	6,151	8,219
Paper and pulp manufacture	2,148	446	417
Pharmaceuticals	5,047	1,945	424
Redistilled	11,697	7,334	8,252
Other	7,734	12,563	7,945
Total	81,354	69,517	75,422

Sources: Statistics for 1964 and 1967 from United States Bureau of Mines Minerals Yearbook, 1967. Statistics for 1968 from United States Bureau of Mines Mineral Industry Surveys, Mercury in the First Quarter of 1969.

*Figure represents combined total; source of reference lists separate figures as follows: general laboratory use—Commercial, 1,583; Government, 15,746.

PPreliminary.

TABLE 5

Average Monthly Prices of Mercury in 1968
at New York and London
($ per flask of 76 pounds)

	New York	London* (U.S. Equiv.)
January	528.32	538.66
February	571.70	598.50
March	571.33	592.00
April	555.57	579.00
May	536.91	564.00
June	510.00	533.14
July	502.64	513.60
August	517.14	524.53
September	541.85	547.20
October	539.74	552.00(Low)–556.80(High)
November	520.42	537.33(Low)–546.40(High)
December	531.05	526.63(Low)–535.20(High)

Sources: *Metals Week* for the New York prices; *Metal Bulletin* (London) for the London prices.

*Exwarehouse prices.

London exwarehouse price, as quoted in *Metal Bulletin (London)*, rose from £220 per flask (76 pounds) at the beginning of January 1968 to a high of £255 around mid-February. Thereafter, the London price displayed a downward trend and reached a low of £214 early in July. From then until the end of the year it fluctuated between £214 and £232.

TARIFFS*

CANADA

	Most Favoured Nation
Mercury metal	free
UNITED STATES	
Mercury ore	free
Mercury metal	20¢ per lb

Sources: The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa. Tariff Schedules of the United States Annotated (1969) TC Publication 272.

*On and after January 1, 1969.

Molybdenum

G.P. WIGLE*

Production of molybdenum in Canada in 1968 was 22.3 million pounds valued at $40.3 million compared with 21.4 million pounds valued at $37.9 million in 1967. Canada was second only to the United States among world producers of molybdenum and supplied approximately 18 per cent of the non-communist world production of 128 million pounds of molybdenum in 1968. As recently as 1963 Canada produced only one per cent of world molybdenum output.

Exploration and development programs on molybdenum and copper-molybdenum properties continued with large capital investment programs well advanced on production facilities for large tonnage low-grade orebodies in British Columbia.

Molybdenum was in oversupply during 1968 with the advent of new producers and the expansion of established molybdenum-producing mines. Production capacity could continue to exceed demand for an indeterminate time as new byproduct and primary molybdenum producers reach production.

PRODUCTION AND DEVELOPMENTS

CANADA

British Columbia Molybdenum Limited, a subsidiary of Kennecott Copper Corporation, completed its first full year of operation at its 6,000-ton-a-day mine and concentrator near Alice Arm, British Columbia. Production in 1968 was 5,090,000 pounds of molybdenum in molybdenite concentrates. The mine is an open-pit operation from which about 6,000 tons of ore and 12,000 tons of waste are removed daily.

Endako Mines Ltd. produced 12,082,373 pounds of molybdenum of which 8,668,087 pounds were in molybdenite (MoS_2) concentrates and 3,414,286 pounds were in the roasted product molybdic oxide (MoO_3). Average grade of ore milled was 0.172 per cent MoS_2. Production was interrupted by a strike from July 27 to November 16; concentrator throughput per operating day was increased from 18,570 tons in 1967 to 25,900 tons in 1968. Ore reserves reported by the company at the end of 1968 were 209.6 million tons averaging 0.148 per cent MoS_2.

Brynnor Mines Limited, Boss Mountain Division, in the Cariboo District of central British Columbia, produced 2,404,000 pounds of molybdenum in MoS_2 concentrates in 1968. The average daily milling rate was 1,410 tons and average grade of ore treated was 0.26 per cent molybdenum. Ore reserves above the adit level were reported to be 3 million tons averaging 0.28 per cent molybdenum. Preparation was completed for sinking an internal shaft to 850 feet below the adit level. Estimated cost of the project was $1.45 million.

Red Mountain Mines Limited, near Rossland in south central British Columbia, milled 537 tons a day averaging 0.28 per cent MoS_2 to produce 549,540 pounds of molybdenum in molybdenite concentrates.

* Mineral Resources Branch.

TABLE 1

Canada, Molybdenum Production, Trade and Consumption, 1967-68

	1967		1968P	
	Pounds	$	Pounds	$
Production (shipments)[1]				
British Columbia	17,824,920	31,368,589	19,575,122	35,481,522
Quebec	3,551,846	6,531,450	2,725,848	4,842,795
Total	21,376,766	37,900,039	22,300,970	40,324,317
Exports				
Molybdenum in ores and concentrates				
Britain	6,547,500	12,211,000	7,185,800	12,690,000
Japan	5,818,700	8,572,000	4,530,800	10,306,000
Netherlands	3,494,200	6,339,000	3,470,100	6,285,000
West Germany	2,021,700	3,591,000	2,774,400	5,505,000
France	1,836,600	3,394,000	1,994,300	3,554,000
Sweden	569,600	1,024,000	1,145,900	2,302,000
Italy	788,100	1,468,000	515,400	956,000
Poland	92,000	163,000	320,100	586,000
Belgium and Luxembourg	701,300	1,343,000	271,800	546,000
Czechoslovakia	176,000	317,000	196,000	354,000
United States	1,357,500	2,722,000	161,400	323,000
Other countries	390,500	598,000	138,500	268,000
Total	23,792,700	41,742,000	22,704,500	43,675,000
Imports				
Molybdic oxide[2]				
United States	452,600	492,000	1,359,300	1,490,000
Ferromolybdenum				
United States[3]	316,692	426,350	284,600	367,243
Consumption (Mo content)				
Ferrous and nonferrous alloys	1,384,858	..	..	..
Electrical and electronics	5,128	..	..	..
Other uses[4]	40,909	..	..	..
Total	1,430,895			

Source: Dominion Bureau of Statistics.

[1] Producers' shipments (Mo content) of molybdenum concentrates, molybdic oxide and ferromolybdenum. [2] Gross weight. [3] United States exports of 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. Imports of ferromolybdenum are not available, separately, in official Canadian Trade Statistics. [4] Chiefly pigment uses.

PPreliminary; .. Not available.

Brenda Mines Ltd., under Noranda Mines Limited management, continued the construction and development program on its large low-grade copper-molybdenum property some 10 miles west of Okanagan Lake in B.C. The property is to be brought into production in the last quarter of 1969, with concentrator capacity of 24,000 tons a day, at an estimated expenditure of $60 million. The orebody was estimated at 176 million tons averaging 0.183 per cent copper and 0.049 per cent molybdenum.

Lornex Mining Corporation Ltd., managed by Rio Algom Mines Limited, completed an extensive program of sampling and test work on its large low-grade copper-molybdenum property in British Columbia's Highland Valley. The program was designed to determine the feasibility of production at a rate of 38,000 tons a day. Drill-hole information was reported to indicate 293 million tons averaging 0.427 per cent copper and 0.014 per cent molybdenum. It was estimated that $120 million would be required to

TABLE 2

Canada, Molybdenum Production, Trade and Consumption, 1959-68
(pounds)

			IMPORTS			
	Production[1]	Exports	Calcium Molybdate[4]	Molybdic Oxide[5]	Ferro-molybdenum[6]	Consumption[7]
1959	748,566	3,748,300[2]	75,987	305,762	164,366	928,505
1960	767,621	..	236,936	656,062	230,600	1,042,077
1961	771,358	..	46,648	266,399	211,779	1,135,610
1962	817,705	..	103,274	328,424	121,358	1,261,380
1963	833,867	..	148,402	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[3]	..	452,600	316,692	1,430,895
1968[p]	22,300,970	22,704,500[3]	..	1,359,300	284,600	..

Source: Dominion Bureau of Statistics.

[1]Producers' shipments (Mo content) molybdenum concentrates, oxide and ferromolybdenum.
[2]Molybdenum concentrates and oxide (gross weight). [3]Mo content, ores and concentrates. [4]Gross weight, including vanadium oxide and tungstic oxide. [5]Gross weight. [6]U.S. exports to Canada reported in United States Exports of Domestic and Foreign Produce, gross weight. [7]Mo content of molybdenum products, reported by consumers.

[p]Preliminary; .. Not available.

TABLE 3

Molybdenum Production in Ores and Concentrates, 1966-68
(Mo content, thousands of pounds)

	1966	1967	1968[e]
United States	90,532	88,930	92,941
Canada	20,596[r]	21,377[r]	22,301
Chile	10,430	10,752	8,418
Peru	1,484	2,037	1,750
South Korea	659	613	
Japan	542	558	
Norway	500	570	(2,108)
Mexico	289	300[e]	
Philippines	108	77	
Total	125,140	125,214	127,518

Sources: Dominion Bureau of Statistics, U.S. Bureau of Mines, Minerals Yearbook; Company annual reports.

[e]Estimated; [r]Revised; .. Not available.

bring the property to production in a period of about 32 months. Annual production was expected to be approximately 54,000 tons of copper and 2.5 million pounds of molybdenum.

Highmont Mining Corp. Ltd. proceeded with a bulk-sampling and testing program on its large low-grade copper-molybdenum property adjoining and east of Lornex. It was reported that Highmont estimated from drill-hole results that its east zone contains 72 million tons averaging 0.25 per cent copper and 0.064 per cent molybdenite.

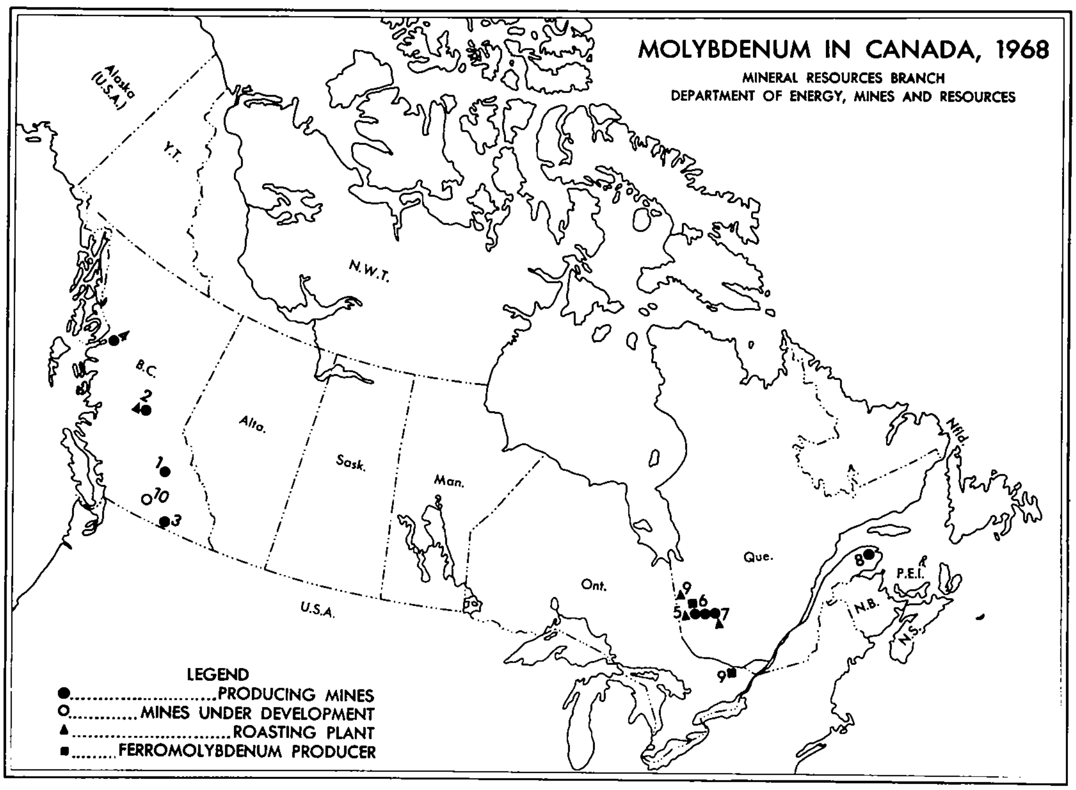
Among many other molybdenum and copper-molybdenum properties in British Columbia explored and studied for their production possibilities were those of Bell Molybdenum Mines Limited near Alice Arm, the Mt. Copeland property of King Resources Company, Sileurian Chieftain Mining Company Limited in the Alice Arm area, Utah Construction & Mining Co. on Vancouver Island, and Valley Copper Mines Limited in the Highland Valley.

Molybdenite Corporation of Canada Limited at Lacorne, Quebec rebuilt its headframe and milling plant and started tune-up operation late in 1968. Fire destroyed the old buildings on October 23, 1967. The company expected to resume full production about

March of 1969. During the 10 years ending September 30, 1967 Molybdenite Corporation produced a total 7,223,477 pounds of molybdenum and 1,328,117 pounds of bismuth metal.

Preissac Molybdenite Mines Limited, and Cadillac Moly Mines Limited (formerly Anglo-American Molybdenite Mining Corporation) both in the Lake Preissac area near Val d'Or, Quebec, produced molybdic oxide and molybdenite concentrates. Gaspé Copper Mines, Limited recovered 511,100 pounds of byproduct molybdenum at its copper operations at Murdochville.

Masterloy Products Limited converted molybdenite concentrates from various producers to molybdic oxide at a roasting plant at Duparquet, Quebec. Masterloy also produced ferromolybdenum at its plant near Ottawa, Ontario.



PRODUCING MINES

(numbers refer to numbers on map)

1. Brynnor Mines Limited (Boss Mountain)
2. Endako Mines Ltd.
3. Red Mountain Mines Limited
4. British Columbia Molybdenum Limited
5. Preissac Molybdenite Mines Limited
6. Cadillac Moly Mines Limited
7. Molybdenite Corporation of Canada Limited
8. Gaspé Copper Mines, Limited

MINES UNDER DEVELOPMENT

10. Brenda Mines Ltd.

PROCESSING PLANTS

2. Endako Mines Ltd.
5. Preissac Molybdenite Mines Limited
7. Molybdenite Corporation of Canada Limited
9. Masterloy Products Limited (roaster and ferroalloy plants)

UNITED STATES

The United States is the largest producer of molybdenum and since 1925 has produced more than half the world supply. United States domestic production in 1968 was 92.9 million pounds of molybdenum compared with 88.9 million pounds in 1967. Domestic supplies were more than adequate, consumption and exports were somewhat reduced and producers stocks were increased.

American Metal Climax, Inc. (AMAX), is the largest single producer of molybdenum with an annual output of 60 million pounds from the Climax and Urad mines in Colorado. AMAX developed and brought into production its second Colorado molybdenum producer, the Urad mine near Empire, in August 1967. The new mine is equipped to produce about seven million pounds of molybdenum a year. Another AMAX project near the Urad, the Henderson deposit, is being developed for production in the 1970's at a proposed rate of 50 million pounds a year. The Henderson orebody is estimated to contain 303 million tons of ore grading 0.49 per cent molybdenite (MoS_2).

The Questa, New Mexico, mine of Molybdenum Corporation of America produced 9.1 million pounds of molybdenum in 1968. Questa mine production capacity is being increased to about 14 million pounds a year.

Duval Corporation is developing an open-pit copper mine in Pima County, Arizona. Production will begin in late 1969 or early 1970 and will include an annual 12 million pounds of molybdenum.

The Anaconda Company is bringing to production, in late 1969, a large new open-pit copper mine at Twin Buttes, Arizona, and provision is being made for the recovery of molybdenum.

CONSUMPTION AND USES

Non-communist world consumption of molybdenum in 1968 was approximately 120 million pounds. The steel and iron industries are the principal consumers of molybdenum, accounting for over 80 per cent of total consumption, the balance being used in high-temperature alloys, molybdenum metal, in lubricants, chemicals, pigments, and in catalysts.

Approximately 68 per cent of United States molybdenum consumption was in the form of molybdic oxide (MoO_3), converted by roasting molybdenite (MoS_2), some 21 per cent was used as ferromolybdenum, and about 4 per cent as molybdenum metal powder. Molybdenum is used in lesser amounts in ammonium, sodium, and calcium molybdate, as purified molybdenum disulphide in lubricants, and as molybdenite for direct addition to steel when sulphur is also to be added.

Small additions of molybdenum promote uniform hardness, hardenability and toughness in steel products. The adding of molybdenum to molten steel is a straightforward operation, losses are small, and addition is commonly made 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 pigment 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.

TABLE 4

United States Consumption of Molybdenum
by Use, 1966-67
(thousands of pounds of contained molybdenum)

	1966	1967
Steel		
High-speed	3,652	2,815
Other alloys including stainless	30,311	26,047
Hot work and other tool	1,275	1,039
Grey and malleable castings	3,419	3,179
Rolls (steel mill)	2,420	1,298
Welding rods	311	281
High-temperature alloys	3,064	4,041
Molybdenum metal wire, rod, sheet and other	2,479	1,595
Chemicals		
Catalysts	1,968	1,838
Pigments and other colour compounds	1,060	990
Miscellaneous*	2,365	6,383
Unspecified		
Total	52,324	49,506

Source: U.S. Bureau of Mines, Minerals Yearbook, 1967.

*Includes magnets, other special alloys, lubricants, packings, forging billets.

Among Canadian consumers of molybdenum and its intermediate products are:

In Nova Scotia: Sydney Steel Corporation, Sydney.

In Quebec: Crucible Steel of Canada Ltd., Sorel; Dominion Engineering Works, Limited, Lachine; Canadian Steel Foundries Division of Hawker Siddeley Canada Ltd., Montreal; Sorel Steel Foundries Limited, Sorel; Canada Iron Foundries, Limited (now Canron Limited), Trois-Rivières.

In Ontario: The Algoma Steel Corporation, Limited, Sault Ste. Marie; Atlas Steels Division of Rio Algom Mines Limited, Welland; Dominion Foundries and Steel, Limited, Hamilton; Fahralloy Canada Limited, Orillia; The Steel Company of Canada, Limited, Hamilton; The Wabi Iron Works, Limited, New Liskeard.

In Manitoba: Amsco Joliette Division of Abex Industries of Canada Ltd., Selkirk.

In Alberta: Irving Industries (Foothills Steel Foundry Division) Ltd., Calgary.

In British Columbia: A-1 Steel and Iron Foundry (Vancouver) Ltd., Vancouver; Cae Machinery Ltd., Vancouver.

PRICES

Published molybdenum prices remained unchanged during 1968.

Prices in U.S. dollars per pound of contained molybdenum f.o.b. shipping point

	Price Changes		
	April 3, 1964	January 11, 1967	December 30, 1968
Molybdenite concentrates,			
95% MoS_2, containers extra	US $1.55	US $1.62	US $1.62
Molybdic trioxide (MoO_3),			
" in bags	1.74	1.81	1.81
" in cans	1.75	1.82	1.82
Ferromolybdenum, 0.12–0.25% C,			
5000 lb lots, lump,	2.04	2.11	2.11
" powder	2.10	2.17	2.17
Molybdenum powder,			
f.o.b. shipping point, hydrogen reduced, per pound			3.63 – 3.75

TARIFFS

	British Preferential	Most Favoured Nation	General
CANADA			
Molybdenum ores and concentrates	free	free	free
Ferromolybdenum	free	5%	5%
Calcium molybdate and molybdic oxide	free	free	5%

UNITED STATES

Molybdenum ore, concentrates
On and after Jan. 1, 1968 – 21¢ per lb on Mo content
" " " " 1969 – 19¢ " " "

Calcium molybdate
On and after Jan. 1, 1968 – 18¢ per lb on Mo content +5%
" " " " 1969 – 16¢ " " " +4.5%

Molybdenum compounds
On and after Jan. 1, 1968 – 18¢ per lb on Mo content +5%
" " " " 1969 – 16¢ " " " +4.5%

Molybdenum metal, unwrought
  On and after Jan. 1, 1968 – 18¢ per lb on Mo content +5%
  " " " " 1969 – 16¢ " " " +4.5%

Molybdenum metal, wrought
  On and after Jan. 1, 1968 – 22.5%
  " " " " 1969 – 20%

Molybdenum metal, waste and scrap (suspended)
  On and after Jan. 1, 1968 – 18.5%
  " " " " 1969 – 16.5%

Ferromolybdenum
  On and after Jan. 1, 1968 – 18¢ on Mo content +5%
  " " " " 1969 – 16¢ " " " +4.5%

Sources: The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa. Tariff Schedules of the United States Annotated (1969), TC Publication 272.

BRENDA MINES LTD, near Peachland, B.C. Open-pit preparation, upper left. Coarse crusher, upper centre. Secondary and tertiary crushing, fine ore bins and mill building, lower centre. Office building, lower left. Service bays, lower right. (Photo by Hunter)

Natural Gas

J.W. FRASER*

The Canadian gas industry successfully met the demands resulting from growth of all sectors in 1968 and continued the record-setting expansion which has become characteristic in recent years. Net new production rose to 1,692,788 million cubic feet, 15 per cent above the 1967 level and well above the 9.7 per cent growth attained in 1967. Sales in domestic markets increased 9.7 per cent to 2,098 million cubic feet daily, essentially duplicating last year's growth. Exports continued to be a bright spot on the marketing scene, growing 17.8 per cent to 1,656 million cubic feet daily, although even this high rate was slightly below the 18.8 per cent expansion in 1967. Imports, mostly into eastern Canada, rose an additional 15.7 per cent to 223 million cubic feet daily but this trend is expected to reverse as the Great Lakes transmission system makes adequate supplies of western Canadian gas available to this rapidly growing market.

Successful exploration and development operations again resulted in the reserve build-up so necessary to support expansion in the marketing sector. In the search for major reserves of sour, wet gas in central- and southwestern Alberta, the highlight of the year was the extension and development of the Kaybob South pool into one of the largest gas fields in Canada. Major reserves were also being developed in the Strachan-Ricinus and Quirk Creek areas of southwestern Alberta, and along the Beaver River-Pointed Mountain trend which extends from the British Columbia-Yukon border into the Northwest Territories. Reserves of marketable gas reached 47,666,461 million cubic feet, up 4.3 per cent, but for the second consecutive time, the annual increase was less than that in the previous year.

Both Westcoast Transmission Company Limited and Alberta and Southern Gas Co. Ltd. received approval for large increases in exports to the United States. Significantly, both companies have applied for further sizable increases, giving an indication of the growth anticipated for the future. Further evidence of future requirements came early in 1969 when both Trans-Canada Pipe Lines Limited (Trans Canada Pipe-Lines Limited) and Northern Natural Gas Company revealed separate proposals to construct major transmission lines from the western Northwest Territories to the mid-western United States. If fully implemented, such proposals would increase exports by an amount almost double the total 1968 export volume. The future, therefore, is promising and sets a target for producers to prove-up the vast reserves required to establish an exportable surplus over and above Canadian requirements.

*Mineral Resources Branch.

TABLE 1

Canadian Natural Gas Fields Producing 10 Million Mcf or More, 1967-68.
(numbers in brackets refer to map location)

	1967 (Mcf)	1968 (Mcf)
Alberta		
Crossfield (1)	115,735,338	142,614,093
Waterton (11)	62,320,415	83,643,297
Westerose South (2)	76,793,307	80,672,917
Edson (19)	63,028,004	74,274,251
Windfall (5)	59,050,630	56,986,688
Medicine Hat (10)	55,158,867	54,731,078
Cessford (4)	55,408,129	53,494,272
Harmattan-Elkton (8)	48,331,401	51,545,271
Harmattan-East (8)	43,043,982	48,595,989
Homeglen-Rimbey (9)	46,246,109	42,699,680
Crossfield East (1)	12,554,930	41,656,846
Carstairs (12)	36,532,893	41,353,222
Pembina (7)	42,464,485	39,742,507
Provost (15)	28,388,333	35,984,665
Nevis (14)	28,008,321	33,340,502
Pine Creek (6)	49,245,144	33,265,682
Carson Creek (13)	27,108,367	31,657,649
Wildcat Hills (20)	28,301,138	31,117,984
Gilby (9)	28,531,819	24,707,479
Minnehik-Buck Lake (23)	22,377,189	22,762,416
Kaybob (25)	16,945,140	21,040,366
Hussar (16)	24,012,752	20,196,598
Sylvan Lake (2)	19,405,905	18,983,870
Jumping Pound (17)	23,309,714	18,950,206
Pincher Creek (3)	18,717,091	17,738,231
Judy Creek (13)	10,042,709	16,413,280
Ghost Pine (28)	2,234,349	14,978,514
Olds (12)	14,722,740	13,923,943
Jumping Pound West (17)	–	13,741,323
Worsley (24)	13,320,360	13,067,931
Fort Saskatchewan (21)	13,229,264	12,997,299
Turner Valley (18)	13,139,481	12,812,673
Bindloss (26)	13,815,253	11,973,010
Swan Hills (13)	9,815,464	10,842,321
Leduc Woodbend (22)	11,904,087	10,745,128
Wayne-Rosedale (28)	11,394,576	10,633,265
Okotoks (29)	11,545,017	10,481,824
Bigstone (25)	–	10,042,982
British Columbia		
Clarke Lake (35)	67,053,152	103,605,080
Laprise Creek (30)	27,223,352	26,857,891
Jedney (30)	20,599,214	19,106,079
Nig Creek (32)	18,771,552	20,278,986
Rigel (34)	15,557,825	15,025,110
Beg (33)	10,741,001	9,924,330
Saskatchewan		
Coleville – Smiley (36)	12,665,308	12,204,535

Source: Provincial government reports. Volumes shown are gross production figures measured at pressure base of 14.65 psia, standard pressure for provincial government statistics.

TABLE 2

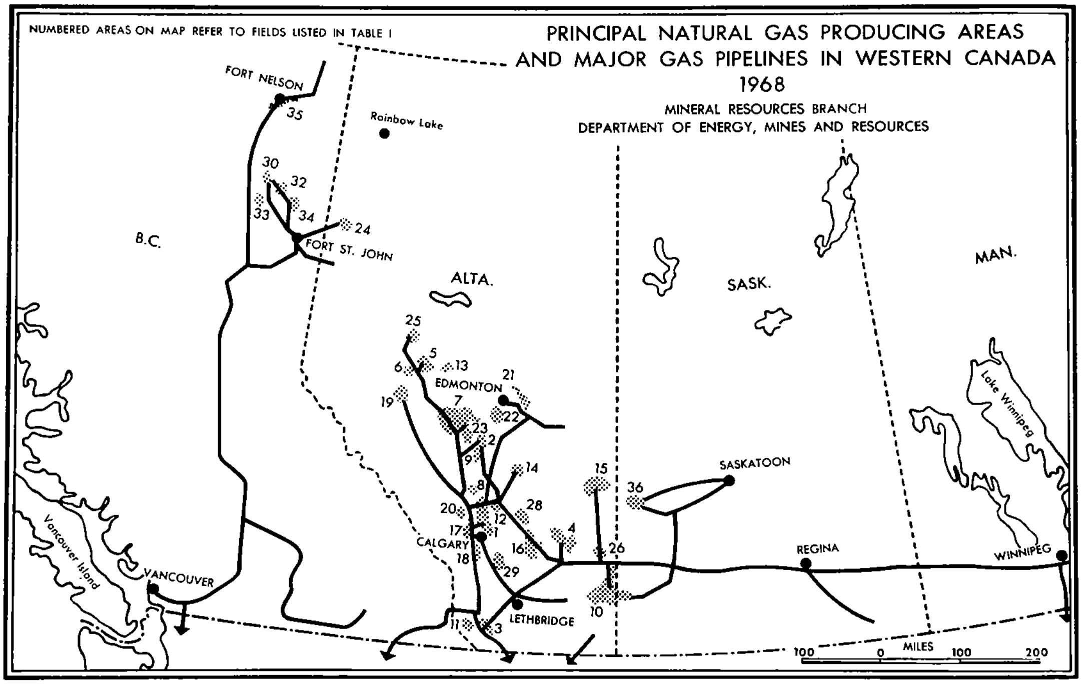
Pressure Maintenance Injection and Storage of Natural Gas in Canada, 1967-68
(Mcf)

	1967	1968p
	Input	Input
Alberta		
Ante Creek	–	425,866
Bigstone	–	1,534,823
Bow Island	1,079,069	–
Carson Creek	25,030,836	26,036,384
Carstairs	1,967,305	2,656,033
Crossfield	8,485,142	10,409,245
Crossfield East	–	7,169,312
Duhamel	143,584	149,596
Gilby	192,822	391,046
Golden Spike	8,840,151	8,467,279
Harmattan-East	39,041,355	38,616,507
Harmattan-Elkton	33,223,077	33,114,498
Joarcam	1,061,941	1,288,827
Joffre	1,879	–
Judy Creek	1,387,844	257,816
Jumping Pound	428,582	164,224
Kaybob South	–	107,000
Leduc-Woodbend	2,186,622	1,176,345
Lookout Butte	9,257,014	–
Pembina	9,700,587	6,472,194
Rainbow	–	3,104,067
Rainbow South	106,715	147,085
Rowley	41,436	1,392
Turner Valley	1,324,907	832,037
Viking Kinsella	4,872,584	–
Waterton	6,111,453	9,546,772
Westerose South	8,159,788	13,975,650
Windfall	57,107,181	46,923,584
Total (14.65 psia)	219,751,874	212,967,582
Volume (adjusted to 14.73 psia)	218,565,213	211,817,557
Ontario	45,500,420	48,986,569
Saskatchewan (14.73 psia)	3,819,560	4,532,164
Total, Canada (14.73 psia)	267,885,193	265,336,290

Source: Provincial government reports.
pPreliminary; –Nil.

PRODUCTION

Production of natural gas increased 15 per cent in 1968, well above the 9.7 per cent growth achieved in 1967. Net new production, which excludes flared, wasted and reinjected gas, amounted to 1,692,788 million cubic feet or an average of 4,638 million cubic feet daily.



In Alberta, the Crossfield gas field increased output by over 23 per cent, maintaining its position as the largest producing field in Canada. Expansion of gas processing facilities permitted a 34 per cent increase at the Waterton field, moving it ahead of the Westerose South field as the second ranking producer in Alberta. Production from the Clarke Lake field near Fort Nelson, British Columbia was increased by over 50 per cent but several other of the main fields in the Fort St. John area experienced small production declines.

A large number of gas fields are being subjected to pressure maintenance in the interests of conservation by having gas reinjected into the reservoir. At others, such as Harmattan-Elkton and Kaybob South, gas is being recycled, and most of the produced gas is returned to the producing reservoir after liquid hydrocarbons and sulphur have been removed. Elsewhere, gas is being stored in depleted fields or subsurface caverns by distributing companies during low demand periods for later uses during the peak winter months. The volumes shown in Table 2 for Ontario, Saskatchewan and the Bow Island and Viking Kinsella fields in Alberta represent such stored gas.

EXPLORATION AND DEVELOPMENT

ALBERTA

The discovery of major reserves of sour, wet gas in the Fox Creek-Clarke Lake area, following the Quirk Creek and Strachan discoveries in 1967, focussed industry efforts in 1968 on the evaluation of prospects in the deep basin and foothills areas of central- and southwestern Alberta. In January, the team of Canadian Fina Oil Limited, Pan American Petroleum Corporation and Hudson's Bay Oil and Gas Company Limited announced the discovery of wet, sour gas in the Middle Devonian, Beaverhill Lake formation at the Fina et al Fox Creek 10-7-60-18W5 well, located approximately 180 miles northwest of Edmonton. Shortly thereafter, the team of Triad Oil Co. Ltd., Mobil Oil Canada, Ltd. and Canadian Superior Oil Ltd. confirmed that its Triad et al. Fox Creek 6-24-60-19-W5 well was a Beaverhill Lake discovery, and a third discovery in the same area, Chevron Clark Lake 11-33-59-18W5 was announced. Initial well data indicated a connection with the Kaybob South pool, 6 miles northwest of the Fina well, and a vigorous exploration and development program has since outlined a continuous reservoir, 2 to 5 miles wide, which extends for 32 miles, making the Kaybob South pool one of the largest, areally and in terms of reserves, in Canada. The gas is very rich in liquid hydrocarbons and sulphur. Reserves in place are estimated at more than 4 million cubic feet. However, the start of gas sales will be delayed for several years to allow for removal of gas liquids by cycling in order to minimize losses due to retrograde condensation of liquid hydrocarbons in the reservoir.

TABLE 3

Canada, Production of Natural Gas, 1967-68
(14.73 psia)

	1967r		1968p	
	Mcf	$	Mcf	$
Gross new production				
New Brunswick	103,879		112,967	
Quebec	59,130		137,573	
Ontario	14,218,140		11,974,385	
Saskatchewan	61,839,433		68,112,212	
Alberta	1,454,894,121		1,633,327,029	
British Columbia	245,542,828		279,425,663	
Northwest Territories	625,491		708,728	
Total, Canada	1,777,283,022		1,993,798,557	
Waste and flared				
Saskatchewan	11,811,407		11,295,574	
Alberta	54,622,016		58,114,759	
British Columbia	12,252,628		11,292,881	
Northwest Territories	584,902		666,126	
Total, Canada	79,270,953		81,369,340	
Reinjected				
Saskatchewan	52,245		35,685	
Alberta	218,344,437		211,817,557	
British Columbia	7,890,852		7,788,471	
Total, Canada	226,287,534		219,641,713	
Net new production				
New Brunswick	103,879	51,939	112,967	56,484
Quebec	59,130	8,870	137,573	20,636
Ontario	14,218,140	5,427,000	11,974,385	4,670,010
Saskatchewan	49,975,781	6,347,000	56,780,953	7,320,520
Alberta	1,181,927,668	162,591,000	1,363,394,713	191,832,623
British Columbia	225,399,348	23,988,000	260,344,311	28,637,874
Northwest Territories	40,589	17,137	42,602	18,006
Total, Canada	1,471,724,535	198,430,946	1,692,787,504	232,556,153
Processing shrinkage				
Saskatchewan	2,290,954		2,477,731	
Alberta	150,256,306		190,043,128	
British Columbia	6,646,766		6,418,702	
Total, Canada	159,194,026		198,939,561	
Net new supply, Canada	1,312,530,509		1,493,847,943	

Source: Dominion Bureau of Statistics.
rRevised; pPreliminary.

Two dual-zone gas discoveries in the same general area have also given promise of substantial new reserves, although neither has been fully evaluated. B.A.-Shell Berland 11-10-58-24W5, 35 miles southwest of the Kaybob South discoveries, found both Wabamun and Leduc gas. The new well is 6 miles southwest of a 1958 discovery which found over 500 feet of Leduc gas pay but has not been put on production. Fifty miles to the northwest, gas was discovered in the Bluesky and Wabamun formations at Pan Am A-1 Karr 7-34-65-3W6, located 12 miles southeast of the Gold Creek Wabamun gas field.

TABLE 4

Canada, Production, Trade and Total Sales of Gas, 1958-68
(Mcf)

	Net new Production	Imports	Exports	Sales in Canada
1958	337,803,726	34,716,151	86,971,932	202,057,485
1959	417,334,527	11,962,811	84,764,116	278,226,823
1960	522,972,327	5,570,949	91,045,510	320,701,484
1961	655,737,644	5,574,355	168,180,412	370,739,542
1962	946,702,727	5,575,466	319,565,908	412,061,509
1963	1,111,477,926	6,877,438	340,953,146	451,598,298
1964	1,327,664,338	8,046,365	404,143,095	504,503,388
1965	1,442,448,070	15,673,069	403,908,528	573,016,494
1966	1,341,833,195	43,550,818	426,223,806	635,514,622
1967[r]	1,471,724,535	52,871,671	505,164,622	698,223,437
1968[p]	1,692,787,504	88,227,825	607,355,445	765,786,814

Source: Dominion Bureau of Statistics. Figures in Tables 4 and 12 differ slightly for imports and exports because of different reporting procedures and timing.
[p]Preliminary; [r]Revised.

TABLE 5

Canada, Liquids and Sulphur Recovered from Natural Gas, 1958-68

	Propane (barrels)	Butane (barrels)	Condensate/ Pentanes plus (barrels)	Sulphur (long tons)
1958	1,123,797	748,972	1,094,653	165,116
1959	1,690,114	1,424,452	2,259,413	261,015
1960	2,064,623	1,536,621	2,460,649	404,591
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[r]	3,273,625[r]	21,759,526	1,281,999
1964	7,615,121[r]	5,656,888[r]	25,275,285[r]	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[r]	1,729,455
1967[r]	14,171,019	9,890,125	30,749,780	2,168,646
1968[p]	15,977,317	10,499,011	33,176,279	3,042,105

Source: Dominion Bureau of Statistics and provincial government reports.
[p]Preliminary; [r]Revised.

One hundred and forty miles southeast of the Kaybob area, three successful 'offset' wells to the 1967 Stampede B.A. Strachan 6-33-37-9W5 Leduc reef discovery have been drilled. All three encountered a greater reef build-up, the thickest being at the B.A. et al. Strachan 11-27-37-9-W5 well which has about 700 feet of net pay. The search for similar reefs in the Ricinus area, 15 miles to the southeast, resulted in the discovery of thick, oil and gas bearing sands in the Upper Cretaceous, Cardium formation, adding impetus to exploration in this area.

At Quirk Creek, 6 miles west of the Turner Valley field in southwestern Alberta, major reserves have been indicated by the completion of four additional wells around the original 1967 discovery, Columbian IOE Quirk 6-5-21-4W5. Although the formally designated limits of the field include 26 sections over an area 9 miles long and 2 to 4 miles wide, the structure is not

TABLE 6

Canada, Wells Drilled, by Province, 1967-68

	Oil		Gas		Dry[1]		Total	
	1967	1968	1967	1968	1967	1968	1967	1968
Western Canada								
Alberta	648	556	283	395	659	897	1,590	1,848
Saskatchewan	421	387	44	47	500	489	965	923
British Columbia	50	46	43	34	93	106	186	186
Manitoba	43	28	–	–	44	38	87	66
Yukon and Northwest Territories	–	2	2	2	38	32	40	36
Westcoast – offshore	–	–	–	–	2	8	2	8
Sub-total	1,162	1,019	372	478	1,336	1,570	2,870	3,067
Eastern Canada								
Ontario	6	9	59	61	81	106	146	176
Quebec	–	–	–	–	–	1	–	1
Atlantic Provinces	–	–	–	–	4	11	4	11
Eastcoast – offshore	–	–	–	–	1	–	1	–
Sub-total	6	9	59	61	86	118	151	188
Total, Canada	1,168	1,028	431	539	1,422	1,688	3,021	3,255

Source: Canadian Petroleum Association.
[1]Includes suspended wells. –Nil.

TABLE 7

Footage Drilled in Canada for Oil and Gas, by Province, 1967-68

	Exploratory		Development		All Wells	
	1967	1968	1967	1968	1967	1968
Alberta	3,812,265	5,039,906	3,929,662	3,747,208	7,741,927	8,787,114
Saskatchewan	1,808,695	1,756,654	1,704,293	1,536,119	3,512,988	3,292,773
British Columbia	606,257	656,669	384,692	394,199	990,949	1,050,868
Manitoba	71,529	63,316	142,131	100,003	213,660	163,319
Northwest Territories	128,944	119,510	–	3,676	128,944	123,186
Westcoast – offshore	19,887	80,822	–	–	19,887	80,822
Total, western Canada	6,447,577	7,716,877	6,160,778	5,781,205	12,608,355	13,498,082
Ontario	141,110	163,614	78,136	130,642	219,246	294,256
Quebec	–	5,990	–	–	–	5,990
Atlantic Provinces	9,190	20,284	–	–	9,190	20,284
Eastcoast – offshore	15,106	–	–	–	15,106	–
Total, eastern Canada	165,406	189,888	78,136	130,642	243,542	320,530
Total, Canada	6,612,983	7,906,765	6,238,914	5,911,847	12,851,897	13,818,612

Source: Canadian Petroleum Association.
– Nil.

yet fully delineated. Pay thickness ranges from 126 feet to 160 feet in the most southerly well. In August, Shell Canada Limited completed a new Mississippian discovery, Shell Whiskey 4-2-22-5W5, 3 miles north of the field limits. However, it is reported to be on a separate structure from Quirk Creek.

Exploration has resulted in a number of other discoveries throughout the province although all are on a smaller scale than those at Kaybob South. In northwestern Alberta discoveries continue to be made in the Upper and Middle Devonian carbonates in the Rainbow and Zama pools, west of Zama in the Shekilie area, and in the region extending north and northwest of Zama to the Northwest Territories border. The lack of pipeline connections tends to retard development in this area, but the plans of The Alberta Gas Trunk Line Company to extend a line to the Zama area by 1971, and more recent proposals to build major pipelines through this area to tap reserves in the Northwest Territories, may soon provide new incentives. In the more established producing areas of central and southern Alberta, the necessity to develop new reserves to meet rapidly growing contract commitments kept exploration and development at a brisk pace. In total, 149 exploratory wells were successful, a sharp increase from 111 in 1967. Development completions increased to 246 from 174 in 1967. Producing wells increased by 277 to1,924, out of 2,356 capable of production.

BRITISH COLUMBIA

Total footage drilled in 1968 increased by about 6 per cent, but successful gas well completions dropped to 34 from 43 in 1967. Two significant Slave Point discoveries were completed in the extreme northeastern corner of the province. Operators of Candel Barnwell H.B. Hoss b-82-G-94-P-14 well, located 65 miles north of the Kotcho Lake field, reported 164 feet of net pay in the Slave Point formation with an estimated open flow potential in excess of 100 million cubic feet per day. The second well, Midwest Chevron Peggo d-65-A-94-P-7, 30 miles northeast of the Kotcho Lake field, is also reported to be a good Slave Point gas well, although no data has been released. As is the case with a number of other Slave Point discoveries in this general area, further development will probably await the arrival of gathering pipelines.

Development of the Beaver River pool, which straddles the Yukon-British Columbia border 100 miles northwest of Fort Nelson, was continued by Pan American Petroleum Corporation in preparation for the extension of the Westcoast Transmission system to this area. After successfully completing the Pan Am Beaver c-45-K well, 2 miles southwest of the original discovery, a second well, Pan Am Beaver c-27-K, was completed 1½ miles to the southwest. Both wells penetrated a thick section of the Middle Devonian Nahanni dolomite reservoir but flow potential has not been revealed. In November, the first northerly extension of the pool, Pan Am Beaver YT G-01, was spudded 2 miles north of the discovery, just inside the Yukon border.

Drilling elsewhere in the province resulted in the completion of 19 exploratory and 15 development wells, down from 25 and 18 respectively in 1967. Wells capable of production increased by 34 to 645.

Off the west coast, Shell Canada Limited drilled an additional eight wells, completing the first phase of its ten-well drilling program which was started in 1967. Although commercial production was not obtained, a thick sedimentary section was encountered with hydrocarbon shows in some areas and, as a result, Shell decided to extend the program, starting an eleventh well in November. In the initial program, the first four wells were drilled off the southwest coast of Vancouver Island near Barkley Sound, while the remainder were drilled several hundred miles north, in the Hecate Strait-Queen Charlotte Sound area. Well depths varied from about 7,500 to over 15,000 feet. In the Pacific Ocean area, offshore acreage under federal permits amounted to 15.4 million acres at the end of 1968, essentially unchanged from 1967.

SASKATCHEWAN AND MANITOBA

Forty-seven gas wells, 5 exploratory and 42 development, were completed in Saskatchewan out of a total of 923 wells drilled, representing a slight increase over the 44 completions in 1967. Most of the development took place in the established Hatton producing area in the southwest part of the province, where both North Canadian Oils Limited and Canadian Homestead Oils Limited undertook development programs under agreements with the Saskatchewan Power Corporation. Operating wells numbered 294, out of 443 capable of production.

In Manitoba, drilled footage declined by about one quarter and since no gas discoveries were made, the province does not yet have commercial gas production. Much of the exploratory effort centred on the evaluation of the sedimentary basin which covers the Hudson Bay Lowlands and extends beneath Hudson Bay. One well, Houston et al.Comeault STH Province No. 1, was drilled and encountered a considerably thinner sedimentary section than a previous test drilled 35 miles to the north on the shore of Hudson Bay in 1967. Increased interest in Arctic and offshore areas generally, and the announcement of plans for drilling the first offshore well in the Bay in the summer of 1969, created a demand for offshore acreage in Hudson Bay. As a result acreage under federal permits rose to 97.8 million acres at the end of 1968, up from 53.9 million in 1967.

NORTHWEST TERRITORIES AND THE YUKON

The major United States oil discovery at Prudhoe Bay on the Arctic coast of Alaska in mid-1968 brought increased attention to similar prospective areas on the Canadian mainland and in the Arctic Islands. The most immediate effect was a land boom covering much of the available onshore and offshore acreage. As a result, land under federal permits in the Northwest Territories and the Yukon increased from 198 million acres to 324 million at the end of 1968. Geological and seismic surveys were under way in some areas in the Canadian Arctic prior to the discovery, but because of the remote location and the problems involved in transporting personnel and supplies, the full effect of the new discoveries is not expected until 1969 and later years, when the tempo of exploration is expected to increase rapidly.

Since drilling related to the new play was limited, only 36 wells were drilled compared to 40 in 1967, and total footage dropped 4 per cent. At the end of 1968, two wells, B.A.-Shell Imperial Tununuk K-10 and IOE Tuk F-18 were drilling in the Mackenzie Delta near the Beaufort Sea, but most of the drilling during the year was in the more southerly areas. In the southwestern corner of the Northwest Territories, Pan American Petroleum Corporation successfully completed a new well 2 miles north of its 1967 Pointed Mountain gas discovery, and started a second well, Pan Am Pointed Mountain G-62, 2 miles to the south. A third well, Pan Am Kotaneelee 0-67 was also started on a similar but separate structure 9 1/2 miles west, close to the Yukon border. In an exploratory program covering the Cameron Hills area straddling the Alberta-Northwest Territories boundary, Hudson's Bay Oil and Gas Company reported two gas discoveries, one in the Territories and one in Alberta, but no details were released.

EASTERN CANADA

In Ontario, both the number of exploratory and development wells and total footage increased in 1968. Slightly more than half the total resulted from offshore drilling, as companies began to evaluate the extensive acreage acquired in 1967. The Consumers' Gas Company and Pan American Petroleum Corporation carried out a successful program on their jointly held acreage in the central portion of the lake. Consumers' Gas independently explored its wholly owned acreage in the eastern end. Atlas Oil and Gas, Limited continued to delineate the producing area near Pelee Point which was discovered in 1967. Onshore, Ram Petroleums Limited discovered a Silurian pinnacle reef in Sombra township which is reported to have established an open flow rate of 14.7 million cubic feet per day.

In total, 73 exploratory wells were drilled, of which 21 resulted in gas discoveries. Seventy-nine development wells were drilled, with 40 successful gas wells. Eighteen of the exploratory wells and 35 of the development wells were Silurian producers, of which 16 were located offshore.

Elsewhere in eastern Canada, drilling was limited, although evaluation of acreage was widespread by geophysical, and to a lesser extent, geological surveys. In Quebec, Sun Oil Company Limited completed an exploratory test in the Matapedia region east of Rimouski at a depth of 5,990 feet without obtaining commercial production. Late in the year, Shell Quebec Limitée, started an exploratory test, Shell St. Hélène No. 1, 20 miles southwest of Drummondville which, early in 1969, reportedly encountered gas.

One exploratory well was drilled in Nova Scotia. Murphy et al. Birch Grove No. 1, located near Glace Bay on Cape Breton Island reached 4,408 feet but was abandoned. Offshore acreage under federal permits increased substantially by more than 50 million acres to 205 million acres at year-end. In preparation for the start of drilling programs off the east coast, two semi-submersible drilling rigs are being built for Southeastern Commonwealth Drilling Ltd. in the Halifax shipyards. One unit will start drilling for Shell Canada Limited in the fall of 1969, while the second will be used by the team of Pan American Petroleum Corporation and Imperial Oil Enterprises Ltd. to evaluate their Grand Banks acreage.

TABLE 8

Canada, Estimated Year-End Marketable Reserves of Natural Gas, 1967-68
(millions of cubic feet)

	1967	1968
Alberta	36,890,431	39,119,502
British Columbia	7,752,745	7,462,938
Saskatchewan	728,967	705,036
Eastern Canada	202,210	222,587
Northwest Territories	107,698	156,398
Total	45,682,051	47,666,461

Source: Canadian Petroleum Association.

RESERVES

Annual estimates compiled by the Canadian Petroleum Association show that proved remaining marketable reserves of natural gas continued to increase in 1968, reaching 47,666,461 million cubic feet by year-end. However, for the second consecutive year both the total increase, 1,984,410 million cubic feet, and the percentage increase, 4.3 per cent, were less

TABLE 9

Canada, Natural Gas Processing Plant Capacities,
by Fields, 1968.
(millions of cubic feet a day)

Main Fields Served	Raw Gas Capacity	Residue Gas Produced
Alberta		
Alderson (2 plants)	24	24
Acheson	6	5
Alexander, Westlock	36	35
Bigstone	48	36
Black Butte	10	10
Bonnie Glen, Wizard Lake	36	30
Boundary Lake South	25	22
Braeburn	16	15
Carbon	1 55	150
Caroline (2 plants)	54	45
Carson Creek	100	15
Carstairs (2 plants)	315	264
Cessford (7 plants)	210	202
Chigwell (2 plants)	12	10
Countess	22	21
Crossfield (2 plants)	290	199
East Crossfield (2 plants)	146	87
Edson	309	280
Enchant	5	5
Ferrier	10	8
Ghost Pine (2 plants)	101	99
Gilby (7 plants)	99	93
Golden Spike	45	reinj.
Harmattan – Elkton, Harmattan-East	246	reinj.
Harmattan – Elkton (2 plants)	47	19
Homeglen – Rimbey, Westerose	422	357
Hussar (2 plants)	100	95
Innisfail	15	10
Judy Creek, Swan Hills (2 plants)	120	96
Jumping Pound	200	160
Kaybob	70	68
Kaybob South, Fox Creek	212	20
Kessler	6	5
Lac La Biche	25	25
Leduc – Woodbend	35	31
Lone Pine Creek	30	24
Minnehik – Buck Lake	70	63
Morinville, St. Albert	22	20
Nevis, Stettler (2 plants)	125	104
Okotoks	30	13
Olds	50	38
Oyen	3	3
Paddle River	30	28
Pembina, Pembalta System (9 plants)	91	74
Pembina (4 plants)	62	56
Pincher Creek	204	145
Prevo	5	4
Princess (3 plants)	19	19
Provost (3 plants)	105	99
Rainbow Lake	38	reinj.
Redwater	11	8
Retlaw	7	7
Samson	3	3
Savanna Creek	75	63
Sedalia	5	5
Sibbald	6	5
Sylvan Lake	28	26
Sylvan Lake, Hespero	62	53
Three Hills Creek	10	9
Turner Valley	100	85
Vulcan	25	16
Waterton	270	170
Wayne – Rosedale (3 plants)	57	54
Wildcat Hills	96	83
Willesden Green	9	8
Wilson Creek	15	10
Wimborne	55	43
Windfall, Pine Creek	215	132
Wintering Hills	20	20
Wood River	5	5
Worsley	55	52
Pipeline at Ellerslie*	70	66
Pipeline at Empress**	1,500	1,460
Saskatchewan		
Cantuar	25	24
Coleville, Smiley	60	59
Dollard	2	2
Hatton – Many Islands	180	180
Milton	4	4
Smiley	4	3
Steelman	38	30
West Gull Lake	15	14
British Columbia		
Fort St. John	395	300
Boundary Lake (2 plants)	27	24
Clarke Lake	530	440
Ontario		
Port Alma	16	16
Corunna (2 plants)	5	5
Becher	1	1

Source: Natural Gas Processing Plants in Canada (Operators' List 7), January 1969, Department of Energy, Mines and Resources.

* Plant reprocesses gas owned by Northwestern Utilities Limited.

** Plant reprocesses gas owned by Trans-Canada Pipe Lines Limited.

than in 1967. Comparable figures for 1967 indicate a 2,231,956 million cubic feet increase giving a growth rate of 5.1 per cent. Extensions to existing pools, amounting to 2,867,357 million cubic feet, accounted for the bulk of the 1968 increase, while revisions added 230,116 million cubic feet. Offsetting these additions were the annual production of 1,394,721 million cubic feet and changes in underground storage of 1,255 million cubic feet.

Alberta accounted for virtually all of the reserve growth, registering a net increase of 2,229,071 million cubic feet after allowing for the year's production and storage withdrawals of 1,099,248 million cubic feet. Reserves in the Northwest Territories increased more than 45 per cent, and Ontario also showed a good percentage gain, although the volumes involved were relatively small. These gains were balanced, however, by a decrease of more than 3 per cent in the second-ranking province, British Columbia, and in Saskatchewan.

NATURAL GAS PROCESSING

In recent years, the strong demand for natural gas liquids and sulphur, has increased the emphasis on exploration for sour, wet gas along the gas prone belt in western Alberta. The successful development of reserves in this area has been followed by the construction of new plants capable of removing a high proportion of the natural gas liquids, such as propane, butane and pentanes plus, as well as sulphur. Many older plants have also been expanded and modified to permit higher recoveries of these products. This trend to development of facilities which provide more complete stripping of the gas stream continued in 1968, but indications of overcapacity for the production of certain liquids has begun to appear and this may influence the design of new plants in the next few years. However, additional raw gas processing capacity will continue to be required to provide the processed, sales gas necessary to meet the rapidly expanding requirements of domestic and export markets.

New construction and expansion of plants in 1968 increased raw gas capacity by 767 million cubic feet and raised the total input capacity of all Canadian plants to 8,457 million cubic feet daily. The plants are designed to recover 6,691 million cubic feet of residue (pipeline) sales gas, 64,605 barrels of propane, 135,046 barrels of pentanes plus and 12,456 long tons of sulphur on a daily basis. This total capacity is distributed amongst 113 plants in Alberta, 4 in British Columbia, 8 in Saskatchewan and 4 in Ontario.

One of the main additions in the processing industry was the large cycling plant built by Hudson's Bay Oil and Gas Company Limited to recover liquid hydrocarbons from the Kaybob South pool. Out of the daily input of 212 million cubic feet of raw gas, the plant can extract a total of 19,830 barrels of natural gas liquids and 1,044 long tons of sulphur. Most of the residue gas, amounting to 136 million cubic feet daily, will be reinjected for a period of several years, in order to minimize losses of liquid hydrocarbons by condensation in the reservoir. Pan American Petroleum Corporation completed its East Crossfield plant, increasing sulphur recovery capacity by 1,500 tons daily. Other new plants were completed at Caroline, Bigstone, Rainbow Lake, Three Hills, Judy Creek, Vulcan, Alderson, Suffield and Lac La Biche in Alberta, and at Gull Lake in Saskatchewan. Installation of facilities designed to increase the recovery of natural gas liquids, and in some cases sulphur also, was undertaken at Sylvan Lake, St. Albert and Jumping Pound in Alberta, and at Fort Nelson in British Columbia. Further substantial expansion of processing capacity in 1969 is indicated by the number of projects planned or under way at the end of 1968.

TRANSPORTATION

An important new link was added to the distribution network of the Canadian gas industry in 1968 with the completion of the Great Lakes Gas Transmission Company trunkline from Emerson, Manitoba to Sarnia, Ontario. Although the line traverses the northern United States, it is jointly owned by TransCanada PipeLines Limited and American Natural Gas Company of Detroit, and is intended primarily to transport western Canadian gas to eastern Canadian markets. The first stage of 36-inch pipe completed in 1967, linked gas storage fields in Michigan to gas storage in Ontario. In the second stage, 814 miles of 36-inch pipeline were constructed following a route from Emerson south of Lake Superior via the Straits of Mackinac to southern Michigan. A 44-mile, 10-inch lateral from the main line north of the Straits serves Sault Ste. Marie, Ontario. To support the larger demand arising from completion of the Great Lakes system TransCanada expanded its Canadian operations. A second loop line was started on the Prairies with the laying of 209 miles of 36-inch line in Manitoba and Saskatchewan, in addition to 17 miles of 36-inch loop on the Emerson extension south of Winnipeg. This marks the beginning of what will become a third line from the start of the TransCanada system at Empress, Alberta to Winnipeg. Thirty-five miles of 12- and 16-inch line were laid in Quebec to connect the Vermont export line to the main system near Montreal. In Ontario, 49 miles of 24-inch loop were installed between Montreal and Toronto, and the Great Lakes system was extended from the International border to Sault Ste. Marie with 6 miles of 10-inch line.

Natural gas service was provided to an area of west central British Columbia for the first time by the construction of the new Pacific Northern Gas Ltd. pipeline. This 389-mile, 6- to 10-inch line connects with the Westcoast Transmission Company Limited trunkline at Summit Lake, north of Prince George, and extends westward to Kitimat and Prince Rupert on the Pacific coast. Westcoast Transmission added 58 miles of 36-inch loop on the main line south of Fort St. John, and increased compressor capacity by 100,400 horsepower. In southern British Columbia, Trans-Prairie Pipelines, Ltd. extended its system with a 35-mile, 8-inch line from Elko to Skookumchuck.

In northeastern Alberta, Albersun Oil and Gas Ltd., a Sun Oil Company Limited subsidiary, completed a 168-mile, 10-inch line from the Tweedie field to Fort McMurray, to provide fuel for the Great Canadian Oil Sands Limited bituminous sand processing project. The Alberta Gas Trunk Line Company laid 35 miles of 36-inch loop on the Princess to Empress section of the main transmission line and added a total of 69 miles of smaller pipe in loops and laterals to connect gas processing plants and new fields. Two of the large gas utilities, Canadian Western Natural Gas Company Limited and Northwestern Utilities, Limited, carried out system expansion, including the installation of about 650 miles of small-diameter, plastic pipe, mostly in rural areas. Other construction in Alberta consisted mostly of construction or extension of gas gathering systems at fields throughout the province.

Saskatchewan Power Corporation continued to expand its system by adding 180 miles of transmission lines, 92 miles of small-diameter laterals and 47 miles of distribution mains in towns and communities. North Canadian Oils Limited expanded the gas gathering system in the Hatton field in southwestern Saskatchewan by 31 miles.

Northern and Central Gas Corporation Limited initiated natural gas service in Sault Ste. Marie, Ontario in November 1968. Gas is obtained via a 50-mile, 10-inch lateral which extends north from the main Great Lakes transmission line to Sault Ste. Marie.

TABLE 10

Gas Pipeline Mileage in Canada, 1964-68

	1964	1965	1966	1967r	1968p
Gathering					
New Brunswick	6	6	6	6	6
Quebec	–	–	–	1	1
Ontario	1,043	1,102	1,167	1,163	1,175
Saskatchewan	389	560	684	714	745
Alberta	3,071	3,120	2,978	2,979	3,166
British Columbia	409	418	484	513	545
Total	4,918	5,206	5,319	5,376	5,638
Transmission					
New Brunswick	13	13	13	13	13
Quebec	25	25	112	121	157
Ontario	3,365	3,390	3,479	3,558	3,665
Manitoba	731	919	956	1,022	1,100
Saskatchewan	3,081	3,288	3,629	3,912	4,199
Alberta	4,776	5,020	5,165	5,327	5,441
British Columbia	1,319	1,551	1,580	1,660	2,049
Total	13,310	14,206	14,934	15,613	16,624
Distribution					
New Brunswick	33	33	33	32	32
Quebec	1,263	1,295	1,361	1,417	1,482
Ontario	12,297	12,699	13,315	13,737	14,477
Manitoba	1,178	1,354	1,344	1,443	1,524
Saskatchewan	1,637	1,740	1,789	1,914	2,030
Alberta	3,383	3,487	3,623	4,296	4,681
British Columbia	3,843	4,053	4,264	4,466	4,628
Total	23,634	24,661	25,729	27,305	28,854
Total, Canada	41,862	44,073	45,982	48,294	51,116

Source: Dominion Bureau of Statistics.
pPreliminary estimate; rRevised; – Nil.

In southwestern Ontario, Union Gas Company of Canada, Limited laid 52 miles of 8- to 20-inch transmission lines, and 500 miles of new distribution lines. The Consumers' Gas Company expanded its gas distribution system with the construction of 240 miles of new lines.

TABLE 11

Canada's Sales of Natural Gas, by Province, 1968p

	Mcf	$	Average $/Mcf	Number of Customers Dec. 31/68
New Brunswick	64,126	186,843	2.91	1,871
Quebec	44,161,824	42,698,601	0.97	215,311
Ontario	307,881,515	253,533,954	0.82	778,494
Manitoba	45,242,862	28,839,079	0.64	117,070
Saskatchewan	81,004,687	34,647,800	0.43	138,482
Alberta	200,935,643	63,884,791	0.32	293,229
British Columbia	86,496,157	66,976,366	0.77	222,553
Total, Canada	765,786,814	490,767,434	0.64	1,767,010
Previous Totals				
1964	504,503,388	327,982,720	0.65	1,459,619
1965	573,016,494	369,307,232	0.64	1,569,539
1966	635,514,622	416,212,202	0.65	1,626,783
1967	698,223,437	454,722,005	0.65	1,689,157

Source: Dominion Bureau of Statistics.
p Preliminary.

MARKETS AND TRADE

Market expansion closely followed the pattern set in 1967, as both the domestic and export sectors showed strong growth, and export sales again increased at almost twice the rate of sales in Canada. Domestic sales rose by 9.7 per cent to 2,098 million cubic feet per day, essentially duplicating the growth achieved in the previous year. Export sales advanced by 17.8 per cent to 1,656 million cubic feet daily, slightly less than the 18.8 per cent growth registered in 1967.

Firm growth continued in both Ontario and Quebec markets as consumers were assured of adequate supplies of Canadian gas with the completion of the Great Lakes pipelines project. Sales in Ontario were up 10.2 per cent to 843 MMcf/d and the province accounted for 40.2 per cent of all sales in Canada. A strong surge in industrial sales gave Quebec a 20 per cent annual increase, the highest of all provinces in 1968, although the total volume represents only about 6 per cent of the Canadian market. Pending the first deliveries through the Great Lakes system in November, TransCanada had to meet immediate demands through imports under a number of short-term contracts. As a result a portion of the market growth in eastern Canada in 1968 was met by imports, as they increased almost 16 per cent above the relatively high 1967 level to 223 million cubic feet daily. However, this trend is expected to be reversed as western Canadian gas displaces imports in the Great Lakes system.

Union Gas Company was unsuccessful in a bid to substantially increase imports into Ontario under its contract with Tennessee Gas Transmission Company. In rejecting the application, the National Energy Board noted that the new Great Lakes line provided a second major transmission line to eastern Canada, giving added security of supply which Union had sought. In addition, the proposed price of the imported gas was only marginally lower than Canadian gas, and NEB suggested this advantage could quickly be erased by expected and relatively small increases in United States prices.

In western Canadian markets, growth was most marked in Saskatchewan and British Columbia, where sales increased by 18 per cent and 15 per cent respectively. Alberta remains the major consuming province in the west, however, and in 1968 consumption averaged 551 million cubic feet daily or 26.3 per cent of total Canadian sales.

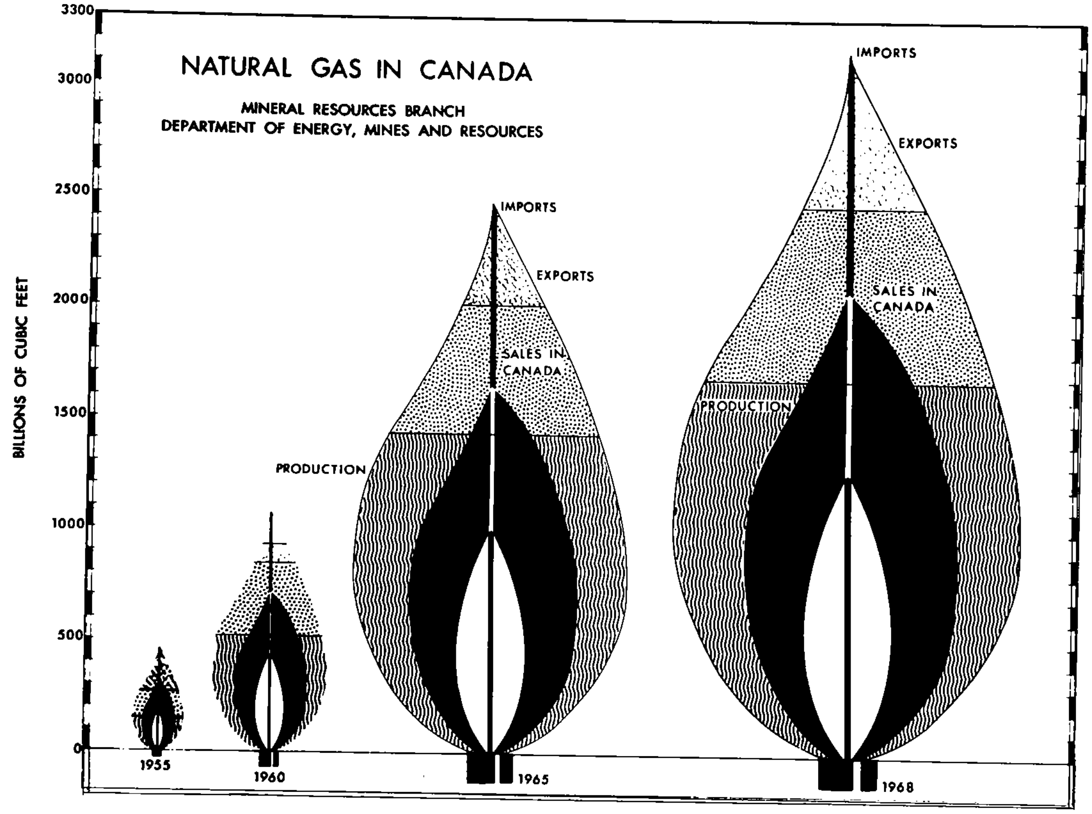
On a volume basis, industrial sales accounted for over 53 per cent of total Canadian consumption, and made up more than half the sales in all provinces except Manitoba and New Brunswick. Residential sales amounted to 28 per cent and commercial sales 18.8 per cent. However because of differences in the unit price of gas to the three different classes of customers, residential sales contributed 46.1 per cent of the $490.7 total revenue from consumer sales compared to 32.4 per cent for industrial sales and 21.5 per cent for commercial sales.

TABLE 12

Canada, Supply and Demand of Natural Gas
(MMcf)

	1967r		1968p	
Supply				
Gross new production		1,777,220		1,993,799
Field waste and flared		− 79,271		− 81,369
Reinjected		−226,288		−219,642
Net new production		1,471,661		1,692,788
Processing shrinkage		−159,194		−198,940
Net new supply		1,312,467		1,493,848
Removed from storage	47,768		55,727	
Placed in storage	−52,639		−57,758	
Net storage		− 4,871		− 2,031
Total net domestic supply		1,307,596		1,491,817
Imports		70,463		81,554
Total supply		1,378,059		1,573,371
Demand				
Exports		513,219		604,445
Domestic Sales				
Residential	204,741		214,584	
Industrial	358,945		407,210	
Commercial	134,537		143,993	
		698,223		765,787
Field and Pipeline Use				
In production	85,490		110,839	
Pipeline	83,758		87,534	
Other	1,002		6,799	
Line Pack changes	− 362		+ 2,749	
Total field, etc. use		169,888		207,921
Gas unaccounted for		− 3,271		− 4,782
Total demand		1,378,059		1,573,371
Total domestic demand		864,840		968,926
Average daily demand		2,369		2,647

Sources: Dominion Bureau of Statistics and Provincial Government Reports.
p Preliminary; r Revised.



Final approval was given during the year to two applications involving substantial increases in exports to the United States. In February, Westcoast Transmission Company Limited received authorization to increase shipments to its main American customer, El Paso Natural Gas Company, following a long series of hearings in which the original application was modified to meet the requirements of Canadian and United States authorities. The original application, approved by the National Energy Board in April, 1967, provided for the replacement of the original El Paso-Westcoast agreement, covering 300 million cubic feet daily, with a new contract for 500 million cubic feet daily which also contained provisions for higher initial price and further price escalation during the contract life. These terms, however, were not acceptable to the Federal Power Commission in the United States and El Paso and Westcoast subsequently submitted several proposals to their respective regulatory authorities before a final compromise was reached. The application approved in February, 1968 by both United States and Canadian authorities provides for additional exports of 202.3 million cubic feet daily at a price of 33.34 cents per thousand feet in Canadian funds, until November 1972, after which it rises to 34.46 cents per thousand. The original contract covering the initial 300 million cubic feet daily was not altered. However, early in 1969, Westcoast and El Paso announced a new agreement calling for additional deliveries of 150 million cubic feet daily through two equal, annual increments of 75 million cubic feet starting on November 1, 1970 and 1971. The proposed price is 32.25 cents (U.S.) per thousand cubic feet increasing to 33.3 cents in November, 1972. If approved, this would raise Westcoast's authorized exports to El Paso to approximately 650 million cubic feet daily.

The second major decision during the year affecting Canadian gas exports was the approval by the FPC of an application by the Pacific Gas Transmission Company to import an additional 200 million cubic feet daily into California from Alberta and Southern Gas Co. Ltd. Alberta and Southern had received NEB approval in June, 1967 to increase exports by a maximum 236 million cubic feet daily, in two equal increments effective in November, 1968 and November, 1969. However, because of a concurrent application by El Paso to increase the domestic gas supply into California, the FPC consolidated the Pacific Gas and El Paso hearings in order to make a broader assessment of several factors affecting the gas supply situation in California and the Pacific northwest area. Consequently, the expansion of facilities in the United States and Canada required to handle the increased gas volumes was delayed pending the results of the hearing. Since approval was not obtained until October, 1968, there was not sufficient excess capacity in the system to fully implement the first increment in November but it is expected the total authorized volume will be available by November, 1969. Total authorized exports for the system now amount to about 838 million cubic feet daily on an average annual basis. In addition, Alberta and Southern recently obtained approval from the Alberta Oil and Gas Conservation Board to increase maximum daily exports to Pacific by 220 million cubic feet daily in two equal annual increments, beginning in November, 1970. Approval of the NEB and FPC will be required before deliveries can be increased under this latter contract.

The outlook for the Canadian gas industry is decidedly expansionary based on a continuation of new-found resources and the strong current demand in both domestic and export markets. Indications of much higher market requirements in the future gives promise of a continuing high level of activity in all sectors of the industry. In the United States, demands for domestic gas reached new records in 1968, and the combination of record sales coupled with relatively poor exploration and development results caused a drop in United States gas reserves for the first time. As a result, the reserves to production ratio in the United States, which is used as an indication of the availability of gas supplies, continued its downward trend, decreasing from 15.9 years to 14.8 years. To meet this tightening supply situation, United States distributors continue to turn to Canada for supplies. Evidence of the potential of the future demand was given early in 1969 when TransCanada PipeLines and Northern Natural Gas Company revealed separate proposals to extend major transmission pipelines from the Northwest Territories to markets in the American midwest. The extent to which Canadian gas will be used to meet total demand will be determined by the ability of producers to prove up the large volumes of reserves required to cover domestic and export requirements. The record to date is remarkably good and all indications are that this record will be upheld.

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, metalworking 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 feedstock 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.

Nepheline Syenite and Feldspar

P.R. COTE*

Nepheline syenite and feldspar were formerly described in separate mineral reviews. There are similarities between these two industrial mineral commodities in physical characteristics, end-use, markets, beneficiation and mining techniques. The declining importance of feldspar and its substitution by nepheline syenite has led to their incorporation into one mineral review.

NEPHELINE SYENITE

In 1932, five claims were staked on the whitish-grey glaciated rocks forming Blue Mountain in Methuen Township some 25 miles northeast of Peterborough, Ontario. Thus began a long period of persistent pioneering and market research that ultimately led to the establishment of a unique industry based on a material–nepheline syenite–now an almost indispensable ingredient in the manufacture of glass. Today, thirty-seven years after the original staking, two mills operate on Blue Mountain drawing rock from three quarries to produce the bulk of nepheline syenite consumed in the world. Only two other countries, Norway and the USSR, produce nepheline syenite.

Nepheline syenite is a white to whitish-grey medium-grained igneous rock resembling granite in texture and is made up of nepheline, potash and soda feldspars and accessory mafic minerals such as biotite, hornblende, and magnetite. The low content of iron-bearing minerals – about 3 per cent which are removed by magnetic separation makes the Blue Mountain material particularly suitable for use in the glass industry.

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 towards this end than all others and over the past thirty years has become a vital ingredient in glass manufacture. Nepheline syenite is an excellent source of alumina and in addition, the material 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 for use in ceramics, enamels, and as a filler in paints, papers, plastics and foam rubber.

CANADIAN PRODUCTION AND DEVELOPMENTS

Canada is the non-communist world's leading producer of nepheline syenite. In 1968, shipments increased 5.9 per cent over 1967 to 425,463 short tons valued at $4,929,446.

Production originates from two mines in Canada, both located on Blue Mountain in Methuen Township some 25 miles northeast of Peterborough, Ontario. The deposit is pear shaped, approximately 5 miles in length, and up to 1.5 miles in width. The iron content of the rock is distributed very uniformly, but 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.

*Mineral Resources Branch.

Indusmin Limited, a subsidiary of Falconbridge Nickel Mines, Limited, operates the largest of the two mills and is located at Nephton, Ontario. This deposit was originally worked by Canadian Nepheline, Limited. Ore is mined from two open pits, the Cabin Ridge and the Craig. Rock is blasted from the pit face and loaded by electric shovels into trucks for haulage to the 1,000-ton-a-day mill. A 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 removed by electro-magnetic methods. Finished products are transported, mostly in bulk, 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 operates a mill on the Blue Mountain deposit some 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 size and iron content suitable for many industrial uses. Reflecting the growing market for nepheline syenite, capacity increases are planned for 1969. Rock is mined from an open pit adjacent to the

TABLE 1

Nepheline Syenite – Production, Exports and Consumption 1967-68

	1967		1968p	
	Short Tons	$	Short Tons	$
Production (shipments)	401,601	4,752,875	425,463	4,929,446
Exports				
United States	282,381	3,138,000	289,883	3,528,000
Britain	8,057	120,000	6,614	142,000
Puerto Rico	2,150	31,000	6,000	86,000
Netherlands	5,125	53,000	5,323	60,000
Italy	3,918	64,000	4,110	59,000
Australia	2,255	48,000	2,942	63,000
Japan	–	–	2,246	35,000
Belgium and Luxembourg	1,736	42,000	1,357	31,000
Venezuela	530	6,000	1,125	14,000
Israel	–	–	749	11,000
Greece	359	6,000	718	14,000
Dominican Republic	–	–	500	7,000
Peru	343	7,000	472	11,000
West Germany	–	–	431	11,000
Other countries	759	17,000	712	17,000
Total	307,613	3,532,000	323,182	4,089,000
	1966		1967	
Consumption (available data)				
Glass	38,351		44,573	
Whiteware	9,243		9,398	
Glass fibre	3,547		3,700	
Mineral wool	252		367	
Porcelain enamel	299		279	
Paint	273		394	
Other	720		841	
Total	52,685		59,552	

Source: Dominion Bureau of Statistics.
pPreliminary.

mill and reserves are sufficient for many years to come. A certain degree of blending from various portions of the pit is required to ensure an acceptable mill feed.

Production is railed, mostly in bulk, to Havelock for distribution to various markets. Approximately 90 per cent of the product is exported to the United States. IMC (Canada) produce three grades of nepheline syenite for glass, ceramic, enamel, fibre and other applications.

TABLE 2

Production and Exports 1959-68
(short tons)

	Production	Exports
1959	228,722	178,120
1960	240,636	193,298
1961	240,320	194,598
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	425,463	323,182

Source: Dominion Bureau of Statistics.

OTHER DOMESTIC SOURCES

Nepheline syenites are known in many localities in Canada, but to date, the Blue Mountain deposit is the only one that has proven to beneficiate 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 was unacceptable due to considerable variation in the nepheline content and an overabundance of iron-bearing accessory minerals.

Nepheline syenite occurs in several localities in southern British Columbia, notably in the Ice River area near Field and in the vicinity of 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 1968, 76 per cent of nepheline syenite produced in Canada was exported; about 90 per cent of this to the United States. Export markets continued to expand and in 1968 reached an all-time high of 323,182 tons – a 5 per cent increase over 1967.

Nepheline syenite is used in a number of industrial applications but more than 75 per cent of production is consumed in the glass industry where, as an additive to the glass batch, it lowers the melting point, promotes melting and is a source of alumina and alkalis. On the average, 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 flint glass. 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	– .50%

A rapidly growing market for finely-ground material in the whiteware industry is developing. 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 both as 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. Approximately 15 per cent of production is consumed in the whitewares industry.

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. Approximately 5 per cent of production is utilized as filler material.

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. These uses are minor and account for less than 5 per cent of consumption.

WORLD REVIEW

The Norsk Nefelin division of Christiania Spigerwerk is western Europe's only producer of nepheline syenite. Production began in 1961 and has increased steadily from 23,000 metric tons in 1963 to 70,000 metric tons in 1968. Production capacity is currently being doubled to 150,000 tons of finished product a year. It is anticipated that by 1970, production from the plant in northern Norway near the village of Hammerfest will reach 200,000 tons of product a year. The lenticular deposit is over 1 mile in length and extends to a depth of at least 750 feet. Both a biotite nepheline syenite and a pyroxene-hornblende nepheline syenite occur in the deposit. Unlike Canadian producers, Norsk Nefelin mines underground, drilling and blasting by conventional techniques. Nepheline syenite is supplied to the glass, ceramic and enamel industries in two main grades; glass grade is about 28 Tyler mesh and ceramic grade, 200 Tyler mesh. The finer mesh ceramic grade material is usually shipped in bags whereas the coarser glass grade is shipped in bulk to European markets. The company employs a modern fleet of coasters on long-term charter and ships finished products to storage and distribution centres in major market areas.

Nepheline syenite is an important source of alumina for aluminum production in the Soviet Union. Very large deposits occur near Kirovsk in the Kola Peninsula and also in the Lake Baikal region of Siberia. The Kola deposits were first mined in the 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

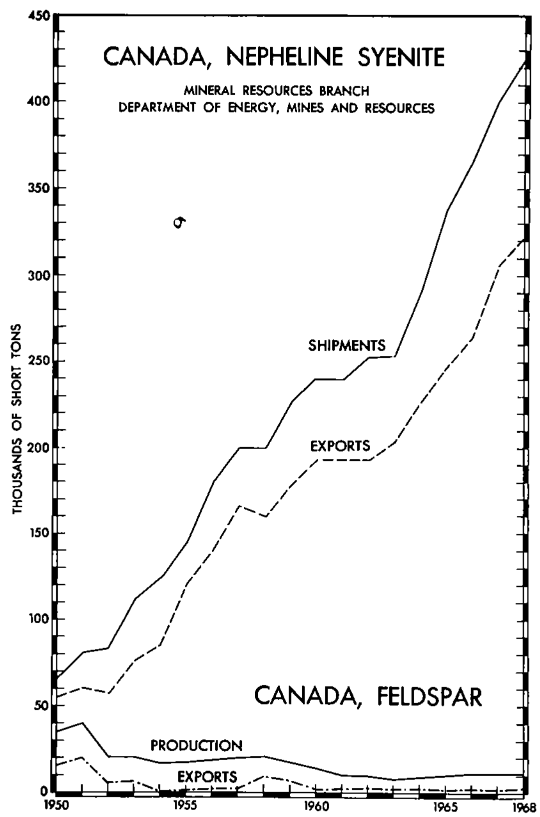
The outlook for nepheline syenite production is excellent. Continual expansions taking place in glass manufacturing capacity assures a steadily increasing market particularly as non-returnable glass containers are becoming more extensively used. The market for finely-ground grades is also expanding and both Canadian producers are operating at capacity to meet these growing consumer demands. Their ability to produce an uninterrupted supply of high quality products with rigid quality control has been the major factor in outlining new market applications. The long term outlook suggests a growth rate in production in the order of 7 per cent a year at least to 1975.

PRICES

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 f.o.b. plant.

TARIFFS

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 containing potassium and sodium 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 other decorative purposes.

Feldspars occur in many rock types but commercially viable deposits are for the most part 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. Producers have, in the past thirty years, experienced increasing competition from other alumina-containing materials—in particular nepheline syenite. Alternative raw materials such as nepheline syenite have made significant inroads into feldspar's markets so that consumption in the manufacture of glass, pottery and enamel has remained at about the same level for the past decade. Feldspar now produced in Canada is consumed in the ceramic industry in southern Ontario and northwestern New York State. The trend towards standardization methods in glass manufacture demanding uniformity of quality has favoured the use of nepheline syenite in a wide range of products formerly utilizing feldspar. Because of its higher alumina content, and consistent quality, nepheline syenite has now completely replaced feldspar in the Canadian glass industry.

CANADIAN PRODUCTION AND DEVELOPMENTS

Production of feldspar in Canada in 1968 was 10,708 tons; all produced by International Minerals and Chemical Corporation (Canada) Limited from their mine at Buckingham, Quebec. Production has remained almost constant, in the order of 10,000 tons a year since the early 1960's and had previously declined steadily from 1947, when some 55,000 tons were produced.

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 feldspars 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; 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 sanitaryware. It must be minus 325 mesh and have a very low quartz and iron content. Mesh size should be at least minus 120 and the iron (Fe_2O_3) content should not exceed 0.1 per cent. For cleaning compounds, feldspar should be white and free of quartz.

TABLE 3

Feldspar – Production 1967-68, Consumption 1966-67

	1967		1968[p]	
	Short Tons	$	Short Tons	$
Production (shipments)	10,394	241,715	10,708	258,723
	1966		1967	
Consumption, available data				
Whiteware	7,173[r]		6,796	
Porcelain enamel	286		270	
Cleaning compounds	690		690	
Other	379		815	
Total	8,528[r]		8,571	

Source: Dominion Bureau of Statistics.
[r]Revised; [p]Preliminary.

TABLE 4

Feldspar, Production and Trade, 1959-68
(short tons)

	Production	Imports	Exports	Consumption
1959	17,953	1,161	7,552	10,129
1960	13,862	1,338	3,183	7,175
1961	10,507	1,721	2,626	7,455
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	8,528r
1967	10,394	..	..	8,571
1968	10,708p	..	..	..

Source: Dominion Bureau of Statistics.
.. Not available; pPreliminary; rRevised.

PRICES

The average price per short ton of Canadian feldspar shipments in 1967 was $23.26 and in 1968, $24.16.

American feldspar prices as published in the January issue of the *Engineering and Mining Journal* were as follows: (all prices quoted are f.o.b. mine in carload lots).

North Carolina	
200 mesh dry ground	$19.50-21.00
40 mesh dry ground	19.50-21.00
200 mesh flotation	19.50
20 mesh flotation	10.00
Georgia	
200 mesh	22.50
325 mesh	23.50
40 mesh granulars	19.50
Connecticut	
30 mesh	12.50
200 mesh	20.50
325 mesh	21.50
20 mesh granulars	12.50
Maine	
200-325 mesh	19.50
Virginia	
200 mesh	20.50
325 mesh	25.50

TARIFFS

	British Preferential	Most Favoured Nation	General
CANADA			
Feldspar, crude	free	free	free
Feldspar, ground but not further manufactured			
Before Jan. 1, 1968	free	15%	30%
On and after Jan. 1, 1968	free	13½%	30%
On and after Jan. 1, 1969	free	12%	30%
UNITED STATES			
Feldspar, crude			
Before Jan. 1, 1968		12.5¢ per long ton	
On and after Jan. 1, 1968		10¢ per long ton	
On and after Jan. 1, 1969		7¢ per long ton	
Feldspar, ground, crushed			
Before Jan. 1, 1968		7.5%	
On and after Jan. 1, 1968		6.5%	
On and after Jan. 1, 1969		6%	

Reductions under the Kennedy Round of the General Agreement on Tariffs and Trade (GATT), that was convened in 1964 and concluded in 1967, were scheduled to lower United States tariffs to free and 3.5% respectively on and after January 1st, 1972.

Source: The Customs Tariffs and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa. Tariff Schedules of the United States, Annotated (1969), T.C. Publication 272.

Nickel

A.F. KILLIN*

In 1968 non-communist world nickel supply again failed to meet demand despite production increases in Canada, Australia and New Caledonia, and sales from the communist bloc nations. The shortfall in production was a continuation of the shortage that has persisted since late 1966, production expansions planned by the major producers in Canada and New Caledonia were delayed by the lack of skilled labour, and no nickel was released in the United States from the government stockpiles.

Consumption** of nickel in the non-communist world declined to 403,500 tons in 1968, compared with the 405,000 tons consumed in 1967. The drop in consumption is attributed to lack of supplies rather than to a decrease in industrial demand.

Nickel production in Canada increased to 263,849 tons from the 248,647 tons produced the previous year. The value of production increased $63,865,367 to $527,005,070 in 1968. Canadian consumption** increased slightly to 11,000 tons in 1968. Canadian exports in 1968 were mainly in the form of ores, concentrates and matte (95,527 tons), oxide sinter (42,058 tons) and refined metal (127,095 tons). The total export of these products rose to 264,680 tons in 1968 compared with 246,525 tons in 1967.

CANADIAN OPERATIONS AND DEVELOPMENTS

Nickel was produced in Quebec, Ontario, Manitoba and British Columbia. Three companies operated integrated mine-mill-smelter and refinery complexes, producing their own ores and treating ores from other mines on a custom basis. In 1968, two mines were closed, three started production and nine were under development for production in the near future.

QUEBEC

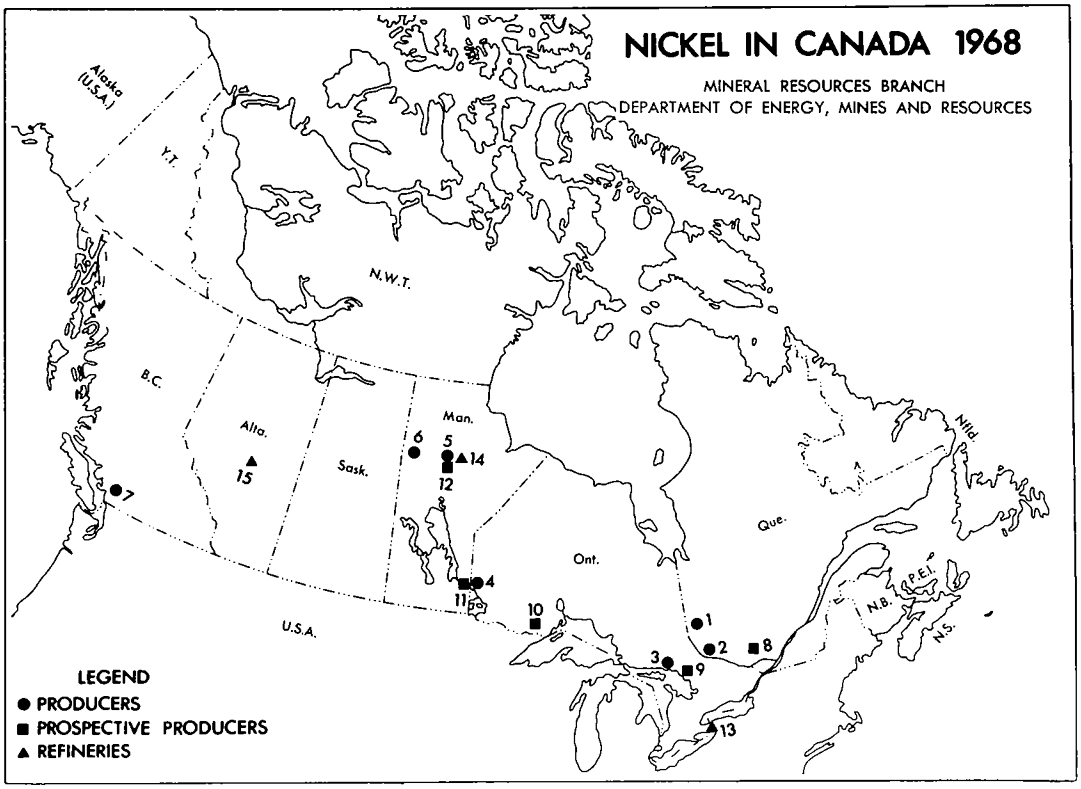
Production ceased during the year from the Belleterre property of Lorraine Mining Company Limited and the Malartic property of Marbridge Mines Limited. Ore reserves at these mines were depleted. New Hosco Mines Limited has agreed to develop to production the Hainaut Township orebody of Renzy Mines Limited. A mill, purchased from the Lorraine operation, will be operated at 600 tons of ore a day.

New Quebec Raglan Mines Limited has started a two-year, $5.6 million, exploration program at its Raglan property in the Cape Smith-Wakeham Bay nickel belt on the Ungava Peninsula. Shaft sinking, underground development and diamond drilling will be done to obtain bulk samples for metallurgical testing and to further explore the known orebodies. A low-grade nickel-copper occurrence has been discovered by diamond drilling to the north of the zinc-copper orebody of Mattagami Lake Mines Limited at Matagami.

ONTARIO

Two of the world's largest producers of nickel operate mines, concentrators and smelters in the Sudbury district of Ontario. The International Nickel Company of Canada, Limited operated 12 mines, four mills and two smelters near Sudbury and a refinery at Port Colborne. The company is developing four new mines in the Sudbury area and a mine at Lake Shebandowan west of the Lakehead. The company has announced plans to build an $85 million pressure-carbonyl type nickel refinery at Copper Cliff to treat part of its projected increase in mine production to 430 million pounds a year by 1972. Falconbridge Nickel Mines, Limited operated eight mines, four mills

* Mineral Resources Branch.
** Estimate by The International Nickel Company of Canada, Limited.



PRODUCERS

(numbers refer to numbers on map)

1. Marbridge Mines Limited
2. Lorraine Mining Company Limited
3. Sudbury area
   Falconbridge Nickel Mines, Limited (8 mines, 1 smelter)
   The International Nickel Company of Canada, Limited (12 mines, 2 smelters), Kidd Copper Mines Limited.
4. Consolidated Canadian Faraday Limited
5. The International Nickel Company of Canada, Limited (Thompson mine and smelter)
6. Sherritt Gordon Mines, Limited
7. Giant Mascot Mines Limited

PROSPECTIVE PRODUCERS

8. Renzy Mines Limited
9. Sudbury area
   The International Nickel Company of Canada, Limited (4 mines)
10. The International Nickel Company of Canada, Limited, Shebandowan mine
11. Maskwa Nickel Chrome Mines Limited
12. Thompson area
    The International Nickel Company of Canada, Limited (3 mines)

REFINERIES

13. The International Nickel Company of Canada, Limited (Port Colborne)
14. The International Nickel Company of Canada, Limited (Thompson)
15. Sherritt Gordon Mines, Limited (Fort Saskatchewan)

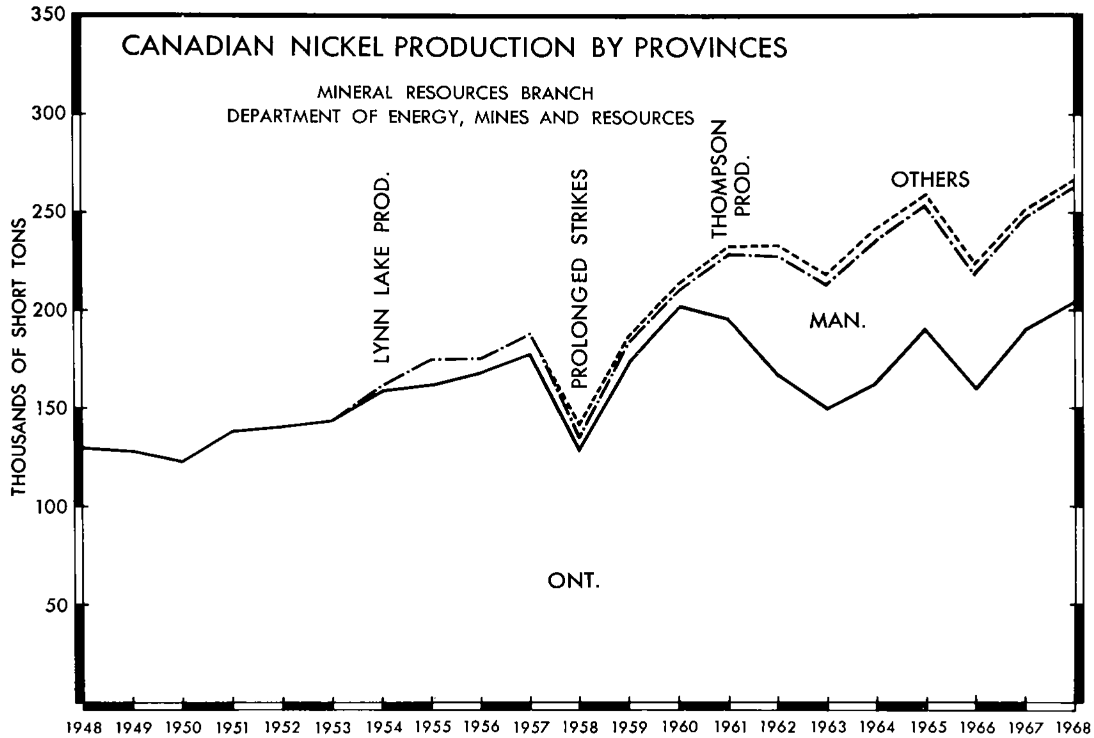


TABLE 1

Canada – Nickel Production, Trade and Consumption, 1967-68

	1967		1968p	
	Short Tons	$	Short Tons	$
Production [1]				
All forms				
Ontario	190,059	352,238,885	203,180	403,563,549
Manitoba	54,714	103,585,379	57,893	117,805,290
British Columbia	2,090	3,946,715	1,672	3,394,160
Quebec	1,622	3,062,499	886	1,800,116
Saskatchewan	162	306,225	217	441,955
Total	248,647	463,139,703	263,848	527,005,070
Exports				
Nickel in ores, concentrates matte and speiss				
Britain	45,939	84,508,000	46,855	92,938,000
Norway [2]	30,328	48,806,000	41,484	74,595,000
Japan	7,264	11,147,000	7,119	12,302,000
United States	120	177,000	69	126,000
Netherlands	11	11,000	–	–
Total	83,662	144,649,000	95,527	179,961,000

TABLE 1 (Cont'd)

	1967		1968P	
	Short Tons	$	Short Tons	$
Nickel in oxide sinter				
United States	22,106	35,847,000	30,510	52,900,000
Britain	4,837	7,692,000	6,346	11,079,000
West Germany	2,653	4,687,000	2,138	4,022,000
Italy	1,657	2,904,000	1,234	2,335,000
Sweden	1,215	2,121,000	897	1,700,000
Australia	958	1,497,000	851	1,466,000
Mexico	36	67,000	40	83,000
France	561	972,000	–	–
Belgium and Luxembourg	158	273,000	–	–
Other countries	23	40,000	42	72,000
Total	34,204	56,100,000	42,058	73,657,000
Nickel and nickel alloy scrap				
United States	1,144	1,147,000	2,028	1,789,000
West Germany	106	215,000	1,239	3,072,000
Britain	195	479,000	233	661,000
Netherlands	224	513,000	215	556,000
Taiwan	–	–	132	430,000
India	18	46,000	124	393,000
Japan	304	786,000	65	222,000
Other countries	22	47,000	91	288,000
Total	2,013	3,233,000	4,127	7,411,000
Nickel anodes, cathodes, ingots, rods				
United States	104,045	176,124,000	98,251	179,993,000
Britain	17,487	28,886,000	21,186	38,537,000
France	1,604	2,951,000	3,161	6,218,000
Australia	1,342	2,439,000	1,473	2,866,000
India	1,064	2,164,000	648	1,452,000
Japan	1,208	2,787,000	591	1,200,000
Brazil	380	718,000	293	669,000
West Germany	213	545,000	249	782,000
Argentina	229	436,000	248	528,000
Mexico	319	667,000	215	476,000
China (communist)	–	–	168	562,000
Italy	188	371,000	155	346,000
Other countries	580	1,143,000	457	1,199,000
Total	128,659	219,231,000	127,095	234,828,000
Nickel and nickel alloy fabricated materials, n.e.s.				
United States	3,258	7,453,000	2,806	7,449,000
Netherlands	21	70,000	327	1,055,000
India	176	371,000	186	541,000
Belgium and Luxembourg	11	33,000	151	346,000
Japan	110	231,000	128	303,000
Republic of South Africa	25	86,000	56	192,000
Brazil	2	4,000	39	108,000
Mexico	39	66,000	35	79,000
Other countries	798	1,752,000	172	533,000
Total	4,440	10,066,000	3,900	10,606,000

TABLE 1 (Cont'd)

	1967		1968p	
	Short Tons	$	Short Tons	$
Imports				
Nickel in ores, concentrates and scrap				
French Oceania	5,261	6,113,000	8,082	7,527,000
United States	4,477	3,725,000	3,713	2,482,000
Britain	4,359	1,506,000	2,400	674,000
Australia	75	44,000	1,695	2,670,000
Republic of South Africa	10	4,000	82	114,000
Other countries	133	151,000	10	19,000
Total	14,315	11,543,000	15,982	13,486,000
Nickel anodes, cathodes, ingots, rods				
Norway	9,507	18,460,000	11,386	23,841,000
United States	48	143,000	8	30,000
Other countries	2	2,000	–	–
Total	9,557	18,605,000	11,394	23,871,000
Nickel alloy ingots, blocks, rods and wire bars				
United States	660	2,090,000	542	2,089,000
West Germany	10	37,000	6	24,000
Other countries	1	3,000	–	–
Total	671	2,130,000	548	2,113,000
Nickel and nickel alloy fabricated materials, n.e.s.				
United States	2,220	8,237,000	2,300	9,373,000
West Germany	409	1,957,000	487	2,146,000
Britain	86	288,000	296	976,000
Other countries	83	336,000	20	103,000
Total	2,798	10,818,000	3,103	12,598,000
Consumption[3]	8,767			

Source: Dominion Bureau of Statistics.

[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, oxide and salts) as reported by consumers.

pPreliminary; –Nil; n.e.s. Not elsewhere specified.

and a smelter at Falconbridge. Nickel-copper matte was exported to the company-owned refinery at Kristiansand, Norway. Consolidated Canadian Faraday Limited continued operations at its Werner Lake mine and mill in northwestern Ontario. Concentrates from Consolidated's mill were shipped to Copper Cliff for smelting and refining.

MANITOBA

The International Nickel Company operates Manitoba's largest nickel mining-smelting-refining complex at Thompson. The company operated the Thompson mine and was developing the Birchtree, Soab and Pipe Lake mines. Production is scheduled to reach 170 million pounds of refined nickel a year by 1972. A 48-mile railway to link the Pipe and Soab mines with Thompson was completed in 1968. Sherritt Gordon Mines, Limited operated Manitoba's second nickel mine and mill at Lynn Lake. Nickel-copper concentrates from the mill were shipped to the company's chemical-metallurgical refinery at Fort Saskatchewan, Alberta. Falconbridge Nickel Mines continued exploration at the Wabowden deposit of Bowden Lake Nickel Mines Limited.

BRITISH COLUMBIA

Giant Mascot Mines Limited near Hope produced all of the 1,672 tons of nickel from British Columbia in 1968. An aggressive program of surface and underground exploration has increased ore reserves at the property and mill capacity will be expanded in 1969.

TABLE 2

Nickel – Production, Trade and Consumption, 1959-68
(short tons)

	Production[1]	Exports				Imports[2]	Consumption
		In Matte etc.	In Oxide Sinter	Refined Metal	Total		
1959	186,555	65,657	4,157	102,111	171,925	1,857	4,059
1960	214,506	73,910	13,257	108,350	195,517	1,762	4,861
1961	232,991	92,938	18,022	133,504	244,464	4,304	4,935
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	5,869
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[p]	263,848	95,527	42,058	127,095	264,680	11,394	

Source: Dominion Bureau of Statistics.
[1]Refined metal and nickel in oxide and salts produced, plus recoverable nickel in matte and concentrates exported.
[2]1959 to 1963 incl., nickel, semi-fabricated, comprising nickel and nickel alloys in ingots, blocks, bars, rods, strip, sheet, etc.; 1960 and subsequent years, refined nickel comprising anodes, cathodes, ingots, rods and shot.
[3]1959, producers' domestic shipments of refined metal; after 1959, consumption of nickel, all forms (refined metal, oxide and salts) as reported by consumers.
[p]Preliminary.

WORLD DEVELOPMENTS

The United States Bureau of Mines estimated that world production of nickel in 1968 totalled 553,000 tons, an increase of 72,000 tons from 1967. Nickel producers have expansion programs scheduled at existing mines but the major increases in production between 1969 and 1975 are expected to come from the development of new mines, especially from the development of the lateritic deposits occurring in the semi-tropical and tropical areas. Increased interest in these deposits has been reported, principally in Australia, the Dominican Republic, New Caledonia, the Republic of the Philippines, Venezuela, Indonesia, Colombia, Brazil and the British Solomon Islands Protectorate. Several new mines have been proposed to develop sulphide nickel deposits in Africa and Australia.

AFRICA

Rhodesia–Anglo American Corporation of South Africa Limited (AAC) started production from the Trojan mine and was developing the Madziwa mine near Shamva for production. These are nickel-copper sulphide deposits and the company is building a smelter and refinery in Rhodesia to treat the concentrates. Capacity of the facility is estimated at 7,500 tons of nickel a year.

The Empress mine of Rio Tinto (Rhodesia) Ltd., about 40 miles west of Gatooma, started production in 1968. Ore reserves were reported at 15 million tons and production was scheduled at 60,000 tons of ore a month. The concentrates were smelted to nickel-copper matte.

Botswana–Nickel-copper sulphide deposits have been discovered in Botswana. Exploration of these deposits is proceeding but the lack of infrastructure, i.e., roads, power, accommodation etc. is a serious deterrent to their development.

AUSTRALIA

Production of nickel in Australia increased in 1968 with expanded output from the Kambalda mine of Western Mining Corporation Limited. Construction of the company's refinery at Kwinana, south of Perth was proceeding and production of 15,000 tons a year of refined nickel is expected by 1971. Concentrates from the mine are presently being refined in Japan and Canada.

Production from the Scotia mine of the Great Boulder–North Kalgurli group is expected in 1969 at 10,000 tons of 3 per cent nickel ore a month. A large number of companies are exploring for sulphide and lateritic nickel deposits in Australia including, International Nickel, Freeport of Australia Inc., Conwest Exploration (Overseas) Limited, Metals Exploration, N.L., Conzinc Riotinto of Australia Limited, The Anaconda Company and New Broken Hill Consolidated Limited.

TABLE 3

Producing Companies, 1968

Company and Location	Mill Capacity (tons ore/day)	Ore Produced 1968 (1967) (short tons)	Grade % Ni	Grade % Cu	Developments
Quebec					
Lorraine Mining Company Limited, Belleterre	400	113,693 (192,532)	0.32	0.59	Mining ceased August 17 when ore reserves were exhausted.
Marbridge Mines Limited, Malartic	350 Milled at Canadian Malartic Gold Mines Limited	54,918 (79,201)	1.45	. .	Ore reserves depleted, mine closed.
Ontario					
Consolidated Canadian Faraday Limited, Werner Lake Division, Gordon Lake	750	207,417 (214,536)	1.05	0.50	Routine exploration and development. Mill being enlarged to 1,200 tpd to accommodate ore from the Maskwa mine in Manitoba.
Falconbridge Nickel Mines, Limited, Falconbridge (Falconbridge, East, Hardy, Boundary, Onaping, Fecunis Lake, Longvack South, Strathcona)	3,000 (Falconbridge) 1,500 (Hardy) 2,400 (Fecunis) 6,000 (Strathcona)	3,086,399 (2,093,507)	1.40	0.80	Routine mining and exploration. Longvack South and Strathcona mines started production. Shaft deepening at the Onaping mine. Smelter expanded to treat concentrates from Strathcona mill.
The International Nickel Company of Canada, Limited, Copper Cliff (Frood, Stobie, Creighton, Garson, Levack, Murray, Crean Hill, MacLennan, Copper Cliff North and Totten mines, Clarabelle and Crean Hill open pits)	30,000 (Copper Cliff) 12,000 (Creighton) 6,000 (Levack) 22,500 (Frood-Stobie)	20,808,500 (16,953,760)	. .	. .	Continued development of four new mines in the Sudbury district and a mine at Lake Shebandowan. Development and increased use of mechanized mining. Building new nickel refinery at Copper Cliff.
Kidd Copper Mines Limited, Aer Nickel mine, Worthington	1,000	241,339 (. .)	0.25	0.42	Mining and development of remaining ore reserves. Operations suspended December 23. Diamond drilling to below the present workings.

TABLE 3 (Cont'd)

Company and Location	Mill Capacity (tons ore/day)	Ore Produced 1968 (1967) (short tons)	Grade %		Developments
			Ni	Cu	
Manitoba					
The International Nickel Company of Canada, Limited, Thompson mine, Thompson	6,000	. . (1,982,201)	. .	. .	Preparation of Birchtree and SOAB mines for production in 1969 and Pipe mine for 1971. Pipe-Thompson railroad completed.
Sherritt Gordon Mines, Limited	3,500	1,276,517 (1,071,490)	. .	. .	Exploration and diamond drilling of N zone above 3,000-foot level. Exploration below 3,000-foot level by diamond drilling.
British Columbia					
Giant Mascot Mines Limited, Hope	1,250	324,569 (333,546)	0.64	0.23	Continued geological, geochemical and geophysical exploration of entire ore zone. Diamond drilling discovered new ore zone. Mill capacity will be expanded.

Source: Company reports.
. . Not available.

TABLE 4

Prospective Producing Companies* 1968

Company and Location	Type of Ore	Mill Capacity (tons ore/day)	Production to Start	Destination of Concentrates
Quebec				
Renzy Mines Limited, Hainaut twp.	Ni, Cu	600	1969	..
Ontario				
The International Nickel Company of Canada, Limited, Copper Cliff				
Kirkwood mine	Ni, Cu	..	1969	Own smelter
Little Stobie mine	Ni, Cu	6,000 (will be milled at Frood-Stobie)	1969	Own smelter
Coleman mine	Ni, Cu	..	1970	Own smelter
Copper Cliff South mine	Ni, Cu	..	1970	Own smelter
The International Nickel Company of Canada, Limited, Shebandowan mine, Shebandowan	Ni, Cu	2,900	1972	Copper Cliff
Manitoba				
The International Nickel Company of Canada, Limited, Thompson				
Birchtree mine	Ni	..	1969	Ore will be shipped to Thompson mill
Soab mine	Ni	..	1969	
Pipe Lake mine	Ni	..	1970	
Maskwa Nickel Chrome Mines Limited, Bird River	Ni, Cu	700 (will be milled at Consolidated Canadian Faraday)	1969	Copper Cliff

Source: Company reports.
*Includes only companies with announced production plans.
.. Not available.

BRITISH SOLOMON ISLANDS PROTECTORATE

International Nickel continued exploration and bulk sampling of the lateritic nickel deposits on the islands of Choiseul, Santa Ysabel and San Gorge.

BRAZIL

Nickel production in Brazil was obtained from two properties. Morro do Niquel S.A. at Pratapolis (Minais Gerais) and Companhia Niquel do Brazil S.A. at Liberdade, produced about 1,200 tons of nickel in ferronickel. Other nickel deposits are being investigated but development is hampered by lack of transportation.

DOMINICAN REPUBLIC

Falconbridge Nickel Mines completed arrangements with the Republic's government for the development of a nickel mining and processing plant to produce 63,400,000 pounds of nickel a year in ferronickel. Production is scheduled for 1971. Armco Steel Corporation of the United States will own 16.4 per cent of a Dominican company set up to develop and mine the deposit.

GUATEMALA

An International Nickel majority-owned subsidiary, Exploraciones y Explotaciones Mineras Izabal S.A. (Eximbal) continued progress on the development of a lateritic nickel deposit near Lake Izabal. Company plans called for the construction of a ferronickel plant capable of producing 50 million pounds of nickel in ferronickel a year. The decision to start construction has not been made because of the company's inability to make final resolution of necessary arrangements with Guatemalan authorities.

GREECE

Société Minière et Métallurgique de Larynma-Larco produced ferronickel for sale in Europe. The electrolytic plant was completed and electrolytic nickel was produced in the first quarter of 1968.

THE REPUBLIC OF INDONESIA

International Nickel entered into an agreement with the Indonesian government for the exploration of nickel deposits in a 25,000 square mile area on the island of Sulawesi. Development will proceed if the deposits are found to be economic.

A consortium of Dutch, American and Canadian companies has signed an agreement with the Indonesian Ministry of Mines covering the exploration and development of low-grade nickel deposits in West Irian. The group Koninblijke Nederlands Hoogovens (22 per cent), Wm. K. Muller N.V. (10 per cent), United States Steel Corporation (43 per cent), Newmont Mining Corporation (15 per cent) and Sherritt Gordon Mines, Limited (10 per cent), will spend a five-to-seven year period of exploration and metallurgical testing of the ores in the region. Preliminary planning calls for a plant to produce 20,000 tons of nickel a year, provided the deposits are amenable to commercial production.

The Sulawesi Nickel Development Cooperation Co. (Sunedico), a joint venture of Japanese nickel smelting companies, operated mines in the Pomala district of Sulawesi (Celebes) Island. Approximately 200,000 tons of lateritic ore was mined and shipped to Japan.

JAPAN

No nickel ores are mined in Japan. The smelters and refiners import lateritic ore from Indonesia and New Caledonia, sulphide ores from Australia and Canada, and nickel matte from Canada and New Caledonia. Two Japanese companies produced electrolytic nickel and three produced ferronickel. Tokyo Nickel Company, owned by Inco (40 per cent), Mitsui and Company (10 per cent) and Shimura Kako Co., Ltd. (50 per cent) produced nickel oxide sinter 75 from matte imported from Inco's plant in Canada.

Nippon Nickel was formed in 1967 by Nippon Yakin, Nippon Mining, Pacific Nickel and Société Le Nickel to produce 5,000 tons of nickel oxide a year from matte supplied by Le Nickel.

NEW CALEDONIA

Société Le Nickel, the non-communist world's second largest nickel producer, operated mines and smelters in New Caledonia and an electrolytic refinery at Le Havre, France. Output of nickel in ferronickel and matte from New Caledonia was 76 million pounds. Le Nickel also exported nearly 500,000 tons of lateritic nickel ore to Japan.

Capacity of the Le Nickel plants will be increased to 71,600 tons, of which 16,500 tons will be sold in the United States by Kaiser Le Nickel Corporation, a joint company established by Le Nickel and Kaiser Aluminum & Chemical Corporation.

International Nickel completed arrangements with a consortium of French companies and with the French government to form Compagnie Française Industrielle et Minière du Pacifique (Cofimpac) to explore and develop lateritic nickel deposits in New Caledonia. If sufficient ore is outlined, the company will build a mining plant and smelter to produce 50 to 100 million pounds of nickel a year.

TABLE 5

World – Production of Nickel
(short tons)

	1967	1968^p
Canada	248,647	263,848
USSR	105,000	114,000
New Caledonia	67,856	90,000
Cuba	26,000^e	40,000
United States	14,615	16,700
Other non-communist countries	19,444	27,000
Total	481,562	551,548

Source: U.S. Bureau of Mines Minerals Yearbook, 1967 and U.S. Bureau of Mines Commodity Data Summaries, for 1968.

^{p}Preliminary; ^{e}Estimated.

VENEZUELA

Société Le Nickel has submitted a proposal to the Minister of Mines for a mine and plant facility to produce 11,000 tons of nickel a year in ferronickel. The deposits to be exploited are in the Loma de Hierro region. If approved by the Congress, Le Nickel will supply technical assistance for the construction of mining and metallurgical installations that will remain the property of a Venezuelan State agency. Le Nickel would own 20 per cent of a Venezuelan company set up to administer the nickel-producing facilities.

CONSUMPTION AND USES

Resistance to corrosion, pleasing appearance and suitability as an alloying agent are the chief advantages in almost all of the uses of nickel. Stainless steel was the largest single outlet for nickel followed closely by nickel plating and high-nickel alloys. Stainless steel use increased in the field of rapid transit and railway car manufacture, in fertilizer and food processing machinery and in architectural applications. High-nickel alloys are used in chemical, marine, electronic, nuclear and aerospace applications.

TABLE 6
Nickel Consumption by Use
(millions of pounds)

	1967	1968[e]
Stainless steels	300	300
Nickel plating	122	121
High-nickel alloys	114	114
Constructional alloy steels	87	92
Iron and steel castings	86	76
Copper and brass products	31	25
Other	70	79
Total	810	807

Source: The International Nickel Company of Canada, Limited.
[e]Estimated.

Non-communist world consumption in 1968 was estimated at 807 million pounds, some 3 million pounds less than in 1967. The drop in consumption was attributed to the shortage of supply. The United States was the world's largest nickel consumer (40 per cent), followed by Western Europe (39 per cent), Japan (16 per cent), Canada (3 per cent), Other (2 per cent).

Table 6 lists the consumption of nickel by use.

PRICES

Prices of nickel in various forms remained stable until almost the year end when International Nickel raised its base price in the United States by 9 cents a pound. Prices in other markets were adjusted to reflect this increase.

PRICES, 1968

	Canada		United States	
	Jan. 1-Dec. 26	Dec. 27	Jan. 1-Dec. 26	Dec. 27
	(cents a pound)			
Inco, electrolytic, f.o.b. Port Colborne, Ont. and Thompson, Man.	101.5	111.25	94.0	103.0
Falconbridge, electrolytic, f.o.b. Thorold, Ont.	101.5	111.25	94.0	103.0
Sherritt Gordon, briquettes or powder, f.o.b. Niagara Falls, Ont. or Fort Saskatchewan, Alta.	105.0	115.0	98.0	107.0
Inco, nickel oxide sinter 75 (Ni-Co content) points in Ontario (freight allowed)	95.50	105.25		
Points outside of Ontario (less freight allowance of 1.25¢ a pound)	95.50	105.25		
Nickel oxide sinter 75 (Ni-Co content) point of entry			88.5	97.5
Nickel oxide sinter 90 (Ni-Co content), point of entry			89.0	98.0

TARIFFS

	British Preferential (%)	Most Favoured Nation (%)	General (%)
CANADA			
Nickel and alloys consisting of 60% or more nickel by weight not otherwise provided for, viz: ingots, blocks and shot; shapes or sections, billets, bars and rods, rolled extruded or drawn (not including nickel processed for use as anodes); strip, sheet and plate (polished or not); seamless tube	free	free	free

TARIFFS (Cont'd)

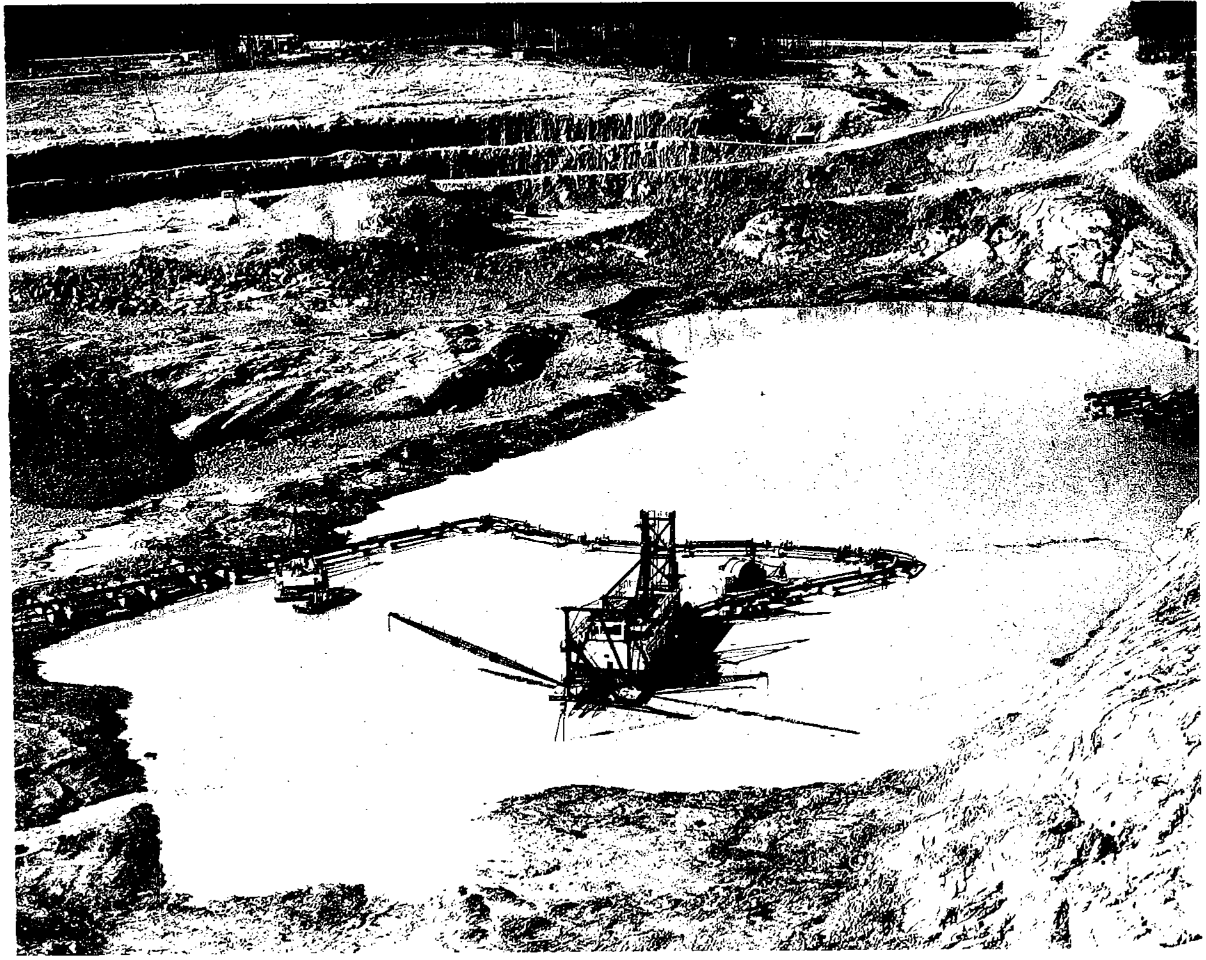
Rods, consisting of 90% or more nickel when imported by manufacturers of nickel electrode wire for spark plugs for use exclusively in manufacture of such wire for spark plugs in their own factories	free	free	10
Metal, alloy strip or tubing, not being steel strip or tubing, consisting of not less than 30% by weight of nickel and 12% by weight of chromium, for use in Canadian manufactures	free	free	20
Anodes of nickel	5	7½	10
Nickel, and alloys containing 60% by weight or more of nickel, in Canadian manufactures (expires June 30, 1968)	free	free	free
Nickel or nickel alloys, namely: matte, sludges, spent catalysts and scrap, and concentrates other than ores, for recovery of the nickel or attendant byproducts (expires June 30, 1968)	free	free	free
Articles or iron, steel or nickel, or of which iron, steel or nickel is the component material of chief value, of a class or kind not made in Canada when imported by manufacturers of electric storage batteries for use exclusively in manufacture of such storage batteries	10	10	20
Ferronickel	free	5	5

UNITED STATES*

Nickel ore, matte and oxide	free
Nickel, unwrought (eff. Jan. 1, 1968)	free
Nickel, waste, and scrap (temporarily suspended)	0.7¢ lb
Nickel, powders (eff. Jan. 1, 1968)	free
Nickel, flakes	8¢ lb
Nickel, electroplating anodes, wrought or cast	8%

Source: Canada, The Customs Tariff and Amendments, Dept. of National Revenue; Tariff Schedules of United States Annotated (1969).

*Effective January 1, 1969 (Most Favoured Nation).



PIPE MINE, THE INTERNATIONAL NICKEL COMPANY OF CANADA LIMITED, Thompson district, Manitoba, Dredge pumping overburden from pit area, foreground. Waste stripping from over the orebody, upper left. (Photo by Hunter)

Petroleum

W. G. LUGG*

Generally, 1968 marked another period of impressive growth. New records were again set as the petroleum industry invested more and earned more than in any previous year. Estimated expenditures on exploration, production and transportation approximated $1,218 million and total field revenue from oil and gas production exceeded $1,277 million. Encouraged by increased demand for petroleum products both in Canada and the United States, daily average production of crude oil and natural gas liquids increased to an average of almost 1,200,000 barrels daily.

Although exploration interest continued high in the Rainbow Lake and Zama Lake areas of northwestern Alberta, no major oil discoveries were made in 1968. Nevertheless, recoverable crude oil and natural gas liquids reserves were increased by 470 million barrels after allowing for 1968 production. The 1967 discovery of large reserves at Prudhoe Bay on the north slope of Alaska focussed the industry's interest in 1968 on the Canadian Arctic. Oil and gas permits in the territorial mainland and Arctic archipelago increased markedly in 1968 and by year-end approximately 324 million acres were under permit there. In the Arctic islands, Panarctic Oils Ltd. selected two Melville Island locations to be drilled in the summer of 1969. The search for oil in Canada's offshore regions is steadily gaining momentum despite the lack of success experienced by Shell Canada Limited's extensive drilling program off the west coast of British Columbia. Preliminary evaluation of offshore areas in Hudson Bay and the Atlantic provinces continued to be expanded and acreage under permit in these areas increased considerably during 1968.

Refinery construction lagged in 1968 with no major additions to plant capacities built but pipeline construction experienced another record breaking year. Value of exports of crude oil and products was about $510 million and notably assisted Canada's balance of payments position.

PRODUCTION

Net Canadian production of all liquid hydrocarbons–crude oil plus natural gas liquids–increased 8 per cent in 1968 to 438 million barrels. Average daily output amounted to 1.20 million barrels. Crude oil output alone amounted to 379 million barrels or 1,036,000 barrels daily and field and gas plant production of natural gas liquids totalled 59.4 million barrels or 162,000 barrels a day. In Alberta, total liquid hydrocarbon production increased over 10 per cent, gained more than 11 per cent in both British Columbia and Manitoba and declined slightly in Saskatchewan and Ontario. Alberta production at 701,000 barrels a day accounted for 68 per cent of the total Canadian crude oil output, 2 per cent greater than last year and Saskatchewan at 24.2 per cent declined 2 per cent. British Columbia contributed 5.7 per cent to total national production, Manitoba 1.6 per cent and Ontario, the Northwest Territories and New Brunswick together, 0.5 per cent. All provinces except Alberta were producing crude oil at near capacity rates. According to the Alberta Oil and Gas Conservation Board, provincial daily developed wellhead capacity was 1.6 million barrels which meant that only about 44 per cent of the province's productive capability was being utilized at the end of 1968.

*Mineral Resources Branch.

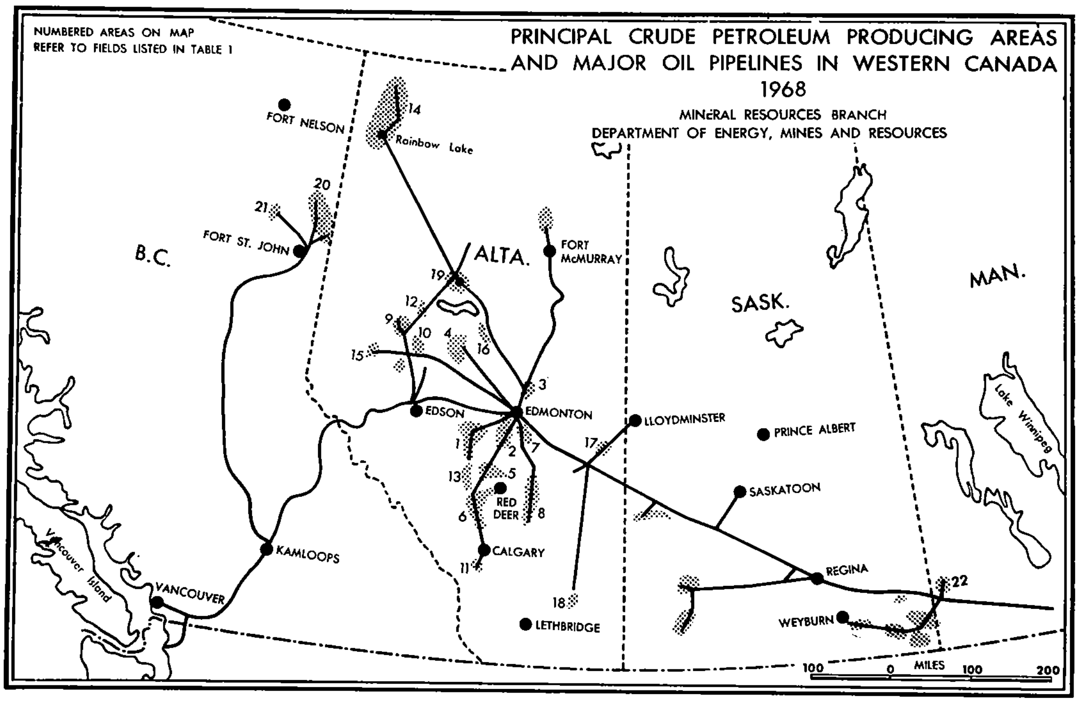


TABLE 1

Production of Crude Oil and Condensate by Province and Field, 1967-68
(number in parentheses gives location of field on the accompanying map)

	1967		1968^{P}	
	Barrels	Bbl/day	Barrels	Bbl/day
Alberta				
Pembina (1)	37,913,113	103,871	39,616,571	108,242
Swan Hills (4)	22,755,379	62,344	25,378,649	69,341
Redwater (3)	16,515,834	45,249	15,917,509	43,490
Golden Spike (2)	16,531,040	45,291	15,867,648	43,354
Judy Creek (4)	12,123,451	33,215	14,246,333	38,924
Rainbow (14)	9,612,128	26,335	13,402,410	36,619
Swan Hills South (4)	8,674,398	23,765	10,054,842	27,472
Bonnie Glenn (2)	8,668,531	23,749	9,792,005	26,754
Leduc-Woodbend (2)	8,044,779	22,040	7,444,435	20,340
Zama (14)	2,669,469	7,314	6,120,208	16,722
Fenn-Big Valley (8)	6,250,692	17,125	5,949,644	16,256
Mitsue (16)	4,914,957	13,465	5,820,767	15,904
Wizard Lake (2)	4,813,963	13,189	5,486,543	14,991
Nipisi (19)	4,462,131	12,225	4,756,524	12,996
Virginia Hills (4)	4,420,202	12,110	4,231,023	11,560
Willesden Green (13)	3,397,791	9,309	3,864,505	10,559
Sturgeon Lake South	3,660,337	10,028	3,549,203	9,697

TABLE 1 (Cont'd)

	1967		1968P	
	Barrels	Bbl/day	Barrels	Bbl/day
Kaybob (10)	2,950,021	8,082	3,496,264	9,553
Carson Creek North (4)	2,714,011	7,435	2,769,446	7,567
Joarcam (7)	2,548,088	6,981	2,550,306	6,968
Acheson (2)	2,467,912	6,762	2,481,296	6,779
Westerose (2)	2,219,403	6,081	2,325,437	6,354
Snipe Lake (12)	2,668,924	7,313	2,266,446	6,192
Medicine River (13)	2,042,558	5,596	2,137,517	5,840
Wainwright (17)	1,847,896	5,062	2,109,635	5,764
Rainbow South (14)	1,345,796	3,687	2,028,632	5,543
Bantry (18)	1,744,343	4,779	2,021,509	5,523
Joffre (5)	1,759,808	4,821	1,716,367	4,690
Innisfail (6)	1,873,903	5,134	1,682,950	4,598
Harmattan-East (6)	1,886,411	5,168	1,675,387	4,578
Kaybob South (10)	1,735,569	4,755	1,617,323	4,419
Clive	1,477,364	4,048	1,499,146	4,096
Harmattan-East (6)	1,886,411	4,290	1,482,069	4,049
Gilby (5)	1,478,136	4,050	1,425,974	3,896
Stettler (8)	1,349,547	3,697	1,255,642	3,431
Virgo (14)	–	–	1,141,161	3,118
Red Earth	872,069	2,389	1,096,668	2,996
Simonette (15)	1,112,333	3,047	1,077,957	2,945
Turner Valley (11)	983,355	2,694	983,377	2,687
Sundre	1,059,526	2,904	935,645	2,556
Other fields and pools	16,412,368	44,965	23,911,605	65,332
Total	231,543,439	634,364	257,186,578	702,695
Total value	$589,925,642		$656,149,366	
Saskatchewan[1]				
Total unit and non-unit areas	92,539,077	253,532	91,879,781	251,038
Total value	$212,330,236		$211,282,702	
British Columbia				
Boundary Lake (20)	6,702,945	18,364	7,807,936	21,333
Peejay (20)	5,144,821	14,095	5,458,180	14,913
Milligan Creek (20)	3,558,644	9,750	3,469,743	9,480
Inga (21)	801,090	2,195	1,647,144	4,500
Other fields and pools	3,489,869	9,561	3,820,224	10,438
Total	19,697,369	53,965	22,203,227	60,664
Total value	$ 44,368,324		$ 50,622,363	
Manitoba				
North Virden-Scallion (22)	2,608,866	7,147	2,866,695	7,832
Virden-Roselea (22)	1,270,585	3,481	1,493,086	4,080
Other fields and pools	1,705,924	4,674	1,843,964	5,038
Total	5,585,375	15,302	6,203,745	16,950
Total value	$ 13,998,849		$ 15,562,275	
Ontario	1,240,298	3,398	1,154,028	3,153
Total value	$ 3,524,123		$ 3,289,974	

TABLE 1 (Cont'd)

	1967		1968P	
	Barrels	Bbl/day	Barrels	Bbl/day
Northwest Territories	677,937[2]	1,857	751,592[2]	2,054
Total value	$ 779,628		$ 864,325	
New Brunswick	8,837	24	7,648	21
Total value	$ 26,953		$ 23,353	
Total, Canada	351,292,332	962,442	379,386,599	1,036,575
Total value	$864,953,755		$937,794,358	

Sources: Dominion Bureau of Statistics and Provincial government reports.
[1]Saskatchewan lists production, by formation rather than by fields.
[2]Excludes stock reinjected into the reservoir.
PPreliminary; – Not reported.

Production from the Great Canadian Oil Sands Limited's Athabasca tar sands project in 1968 averaged less than 15,000 barrels daily as the plant was still experiencing some operating problems. To bring it up to peak capacity of 45,000 barrels a day, additional modifications will be made in 1969.

The proration of production of medium and light gravity crude oil in Alberta continued to be modified in accordance with the new system established in 1965. The new system was introduced to prorate production among pools in proportion to their recoverable reserves rather than by the number of wells in a pool and well depth. The system has been gradually implemented over the past four years and will become fully operative in May 1969. When fully effective it will result in the high reserves per acre fields such as Rainbow and Golden Spike obtaining a relatively high proportion of allowable production.

RESERVES

Canada's liquid hydrocarbon reserves, which include conventional crude oil and natural gas liquids, did not gain appreciably in 1968. The Canadian Petroleum Association estimated that proved remaining reserves in Canada had risen by 470 million barrels to a year-end total of 10,018 million barrels. This is comprised of 8,382 million barrels of crude oil and 1,636 million barrels of natural gas liquids. Of the total increase for 1968, 131 million barrels were attributed to new discoveries, 518 million barrels to revisions and another 254 million barrels to extensions of existing fields. At the current level of production of 438 million barrels a year, the life index for Canadian crude oil and natural gas liquids dropped from 24 years in 1967 to 23 years in 1968.

Alberta accounted for practically all of Canada's reserve growth in 1968 with a net gain of 486 million barrels. Except for Ontario and Manitoba, the reserve position of all other provinces declined. For the first time the Canadian Petroleum Association included estimates of reserves of non-conventional crude oil as part of its estimates. These were placed at 6.3 billion barrels. The assessment was made on the reserves that could be recovered by Alberta's only existing oil sands plant–the Great Canadian project 20 miles north of Fort McMurray. Reserve estimates were restricted to the "economic radius" or 5 miles around the plant with an overburden-to-pay section of one to one. Ultimate reserves for the Athabasca type oil sands by all known methods of recovery, including both mining and in situ processes, have been estimated by the Alberta Oil and Gas Conservation Board at over 300 billion barrels.

Heavy oil reserves in the Saskatchewan-Alberta border area near Cold Lake have been unofficially set as high as 80 billion barrels. This oil is about 11° API gravity, and is intermediate in viscosity between the heavy crude oil of Lloydminster and the bitumen of the Athabasca sands. The oil is too deep to be recovered by open-pit mining methods and too viscous to be recovered by conventional oil producing techniques. At the present time there are several experimental thermal recovery pilot projects being conducted in the Cold Lake area. Some are approaching the stage whereby they can be placed on a full scale operational basis.

TABLE 2

Production of Natural Gas Liquids by Province, 1967-68

	1967r		1968p	
	Barrels	Bbl/day	Barrels	Bbl/day
Alberta				
Propane	12,872,669	35,268	14,633,683	39,983
Butane	8,908,098	24,405	9,564,976	26,134
Pentanes plus	28,568,987	78,272	31,050,939	84,839
Condensate	828,198	2,269	786,443	2,148
Total	51,177,952	140,214	56,036,041	153,104
Saskatchewan				
Propane	885,292	2,425	942,834	2,576
Butane	393,909	1,079	406,489	1,111
Pentanes plus	295,980	811	324,482	886
Total	1,575,181	4,315	1,673,805	4,573
British Columbia				
Propane	413,058	1,131	400,800	1,095
Butane	588,118	1,612	527,546	1,441
Pentanes plus	1,016,045	2,783	960,252	2,624
Condensate	40,570	111	54,163	148
Total	2,057,791	5,637	1,942,761	5,308
Canada				
Propane	14,171,019	38,825	15,977,317	43,654
Butane	9,890,125	27,096	10,499,011	28,686
Pentanes plus	29,881,012	81,866	32,335,673	88,349
Condensate	868,768	2,380	840,606	2,296
Total	54,810,924	153,084	59,652,607	162,985
Returned to formation	44,015	3,038	198,903	543
Total net production	54,766,909	150,046	59,453,704	162,442

Source: Provincial government reports.
pPreliminary; rRevised.

TABLE 3

Value of Natural Gas Liquids by Province, 1957-68 ($ thousands)

	1967	1968p
Alberta	106,321	115,393
Saskatchewan	2,581	2,797
British Columbia	3,878	3,533
Total, Canada	112,780	121,723
Volume (thousand bbl)	52,091	57,231

Source: Dominion Bureau of Statistics and Provincial government reports.
pPreliminary.

EXPLORATION AND DEVELOPMENT

ALBERTA

Prospects for finding oil in Alberta continued high and contributed to a large increase in exploratory drilling in 1968. Development drilling was not as intensive as in previous years, modified in some respects by the fact that developed fields were producing at greatly reduced capacities and emphasis in 1968 was more strongly oriented generally towards exploration. Nevertheless, total provincial drilling increased 13 per cent to 8.8 million feet and accounted for about 64 per cent of the Canadian total.

There were no major oil discoveries in Alberta during the year. The Rainbow-Zama Lake area of northwestern Alberta continued to be the centre of much industry activity but exploration there has progressed to a more mature stage and the previous tempo has slackened. However, several new pools were discovered in this region and resulted in the designation of three new fields: the Virgo field which abuts the Zama field to the south; the Amber field, just west of the Virgo field and the Tehze field, located between the Rainbow and Rainbow South fields. Another significant oil resource appears to be shaping up about 1/2 mile west of the Keg River B pool and 3/4 of a mile northeast of the Keg River D pool. The discovery well there penetrated over 430 feet of oil pay in a Keg River reef. The principal producing horizon of all of these pools is the Keg River formation of Middle Devonian age.

In central Alberta a dual zone strike 3-1/2 miles south of the Clive oil field has revived interest in the area. Commercial production was indicated from both the Devonian Nisku and Leduc formations. Major additions to provincial reserves were discovered when three successful stepout wells were drilled near the southeastern tip of the Mitsue field. These wells substantially expanded the field limits and development was continuing at year-end. A major sour, wet gas discovery was made in the South Kaybob area. The producing formation is the Beaverhill Lake of Devonian age and the areal extent of the field has been tentatively set at 60,000 acres. Preliminary estimates indicate that this is the largest gas field in terms of reserves in Canada and may be one of the largest in North America. Major gas processing and cycling plants have been proposed for this new field and are awaiting government approval. When fully developed it will contribute a very large volume of natural gas liquids to provincial production totals. A small Mississippian pool in the Cherhill area of central Alberta was discovered in 1968 and by the year-end six oil wells had been completed in this new field designated the Alexis field by the Oil and Gas Conservation Board.

Early in 1969 an indicated oil discovery was made in the fringing Keg River reef in the Senex Creek area of north-central Alberta. Although the results of several follow-up wells proved to be disappointing, the discovery did open up a sizeable new trend for future exploratory effort. In the Chauvin area of east-central Alberta, a dual zone heavy oil discovery was made in the Sparky and Lloydminster formations.

The bulk of the oil field development occurred in the Zama and Rainbow Lake districts of northwestern Alberta as was the case last year. As an indication of work carried out in 1968, the Alberta Oil and Gas Conservation Board had designated 69 Keg River, 18 Muskeg, and 6 Sulphur Point producing oil pools in the Zama field area; and 46 Keg River and 5 Muskeg oil pools in the Rainbow area.

The recently discovered South Chauvin heavy gravity crude oil field is rapidly being expanded as more than 15 development wells were drilled there during 1968. The new pipeline from the Chauvin field to Hardisty on the Interprovincial Pipe Line Company's pipeline will ensure rapid development of this pool. Other areas that received considerable attention were the Nipisi, Hamilton Lake and Willesden Green fields.

The gradual implementation of Alberta's prorationing regulations during the last three years continued to ensure that Alberta would maintain its

TABLE 4

Crude Oil – Production, Trade and Refinery Receipts, 1958-68
(barrels)

	Production[1]	Imports[2]	Exports[2]	Refinery Receipts[3]		
				Domestic	Imported[4]	Total
1958	165,496,196	104,038,800	31,679,429	134,513,998	107,444,741	241,958,739
1959	184,778,497	115,288,643	33,362,234	151,507,774	116,342,270	267,850,044
1960	189,534,221	125,559,631	42,234,937	149,259,745	126,824,208	276,083,953
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
1968p	379,386,599	177,738,586	167,487,968	236,178,376	177,293,134	413,471,510

Source: Dominion Bureau of Statistics.
[1]Alberta field condensate is excluded from the statistics for 1960, 1961 and 1962. [2]Trade of Canada (DBS) data. [3]Refinery receipts include condensate and pentanes plus. [4]Imported includes some partly processed crude. [p]Preliminary.

TABLE 5

Reserves of Crude Oil, 1967-68

Province or Region	At end of 1968 (thousand barrels)	Per Cent of Total 1967	Per Cent of Total 1968	Net Change Since 1967 (thousand barrels)
Alberta	7,253,019	86.0	86.5	+222,970
Saskatchewan	720,503	8.9	8.6	– 5,100
British Columbia	287,246	3.6	3.4	– 7,000
Northwest Territories	46,959	0.6	0.6	– 889
Manitoba	67,713	0.8	0.8	+ 1,697
Eastern Canada	6,173	0.1	0.1	+ 1,011
Total	8,381,613	100.0	100.0	+212,689

Source: Canadian Petroleum Association.

TABLE 6

Reserves of Liquid Hydrocarbons at End of 1968

	Natural Gas Liquids (thousand barrels)	Crude Oil Plus Natural Gas Liquids (thousand barrels)	Per Cent of Total
Alberta	1,588,769	8,841,788	88.3
Saskatchewan	9,359	729,862	7.3
British Columbia	37,833	325,079	3.2
Other areas	–	120,845	1.2
Total	1,635,961	10,017,574	100.0

Source: Canadian Petroleum Association.
– Nil.

position as the outstanding province for enhanced recovery operations. The additional reserves attributed to an enhanced recovery scheme entitles the operator to a larger production allowable under the new proration system. The largest waterflood of the past year was installed in the Mitsue field. Ultimate recovery there will be increased by 167 million barrels by the injection of 30,000 barrels of water daily. Another large waterflood project was brought into operation in the Goose River field in June of 1968. Ultimate recovery is expected to be increased by 37 million barrels. A major waterflood in the Rainbow "B" pool was initiated in January with the expectation of adding another 50 million barrels of ultimate reserves to the pool's total. At year-end there were several large enhanced recovery schemes awaiting regulatory approval. Many of these were miscible flood schemes scheduled for the Rainbow Lake pools.

Early in 1968, the Alberta government introduced a new policy that raised the oil production limits for the Athabasca bituminous sands from a daily allowable of 45,000 barrels to 150,000 barrels. As a result of this policy change, Syncrude Canada Ltd. re-applied to the Alberta Oil and Gas Conservation Board for a permit to build an oil sands plant near Fort McMurray, Alberta estimated to cost more than $190 million. The application called for a daily production of 50,000 barrels of synthetic crude oil, 25,000 barrels of specialty oils, and 5,000 barrels of naphtha. In order to facilitate production plans, Syncrude agreed to delay start-up time until 1976-77 from the original target of 1972-73. The delay in putting the plant into operation was considered necessary in order to assess the potential impact that future Prudhoe Bay production would have on markets in the United States and also to assure opponents of the scheme that conventional Alberta crude oil markets in the United States would not be pre-empted. By year-end, the Board had not reached a final decision on Syncrude's application.

SASKATCHEWAN

Several discoveries were made in Saskatchewan during 1968 which subsequent drilling proved as minor accumulations. The lack of new discoveries is beginning to adversely effect aggregate drilling as both exploration and development footage declined this year. Exploratory drilling, at 1,757,000 feet, was down 3 per cent and development drilling at 1,536,000 feet dropped 10 per cent. Of the 115 pre-Mississippian tests completed this year, only two were successful and both of them were drilled in the southeastern corner of the province. The most important of these was a Nisku discovery completed by Jefferson Lake Petrochemicals of Canada Ltd. in the Kisbey area. This venture is Saskatchewan's second discovery of a commercial deposit of Devonian oil, the first being the Hummingbird field about 80 miles west of Kisbey. Another Nisku discovery was made in the Ceylon area of southeastern Saskatchewan—neither of these finds were large, although they did point up the potential for Devonian production in this region.

The Middle Devonian Winnipegosis formation continued to be a prime exploration target but so far the limited number of wells which have tested it have been unsuccessful. A notable exploratory venture to assess relatively unexplored areas was undertaken by Pheasant Exploration Ltd., a company organized to evaluate the Winnipegosis formation over a 22 million acre block in central Saskatchewan. Pheasant is composed mainly of a group of major landholders in the area. By year-end more than 20 wells of the proposed program had been drilled, all of which were dry and abandoned but valuable geological data was obtained.

In oil field development, the Plato, Viking sandstone pool of western Saskatchewan is rapidly being expanded. Fourteen successful follow-up wells have been drilled subsequent to the initial discovery made in 1967. In addition, several wildcat wells drilled in the same general area have been completed as oil wells confirming the existence of a promising Viking productive trend.

The Jurassic oil fields of southwestern Saskatchewan continued to be expanded during 1968. Most

TABLE 7
Wells Completed and Footage Drilled

	1955		1960		1967		1968	
	No.	Footage	No.	Footage	No.	Footage	No.	Footage
WESTERN CANADA								
West coast-offshore								
New field wildcats	–	–	–	–	2	19,887	8	80,822
British Columbia								
New field wildcats	34	194,014	60	365,818	23	156,425	55	385,606
Other exploratory	2	13,020	11	55,749	89	449,831	51	271,063
Development	–	–	72	331,740	74	384,692	80	394,199
	36	207,034	143	753,307	186	990,949	186	1,050,868
Alberta								
New field wildcats	307	1,773,980	338	2,078,876	473	2,380,983	485	2,593,825
Other exploratory	105	436,941	223	1,171,079	297	1,431,282	534	2,446,081
Development	1,208	6,219,810	1,131	7,125,856	820	3,929,662	829	3,747,208
	1,620	8,430,731	1,692	10,375,811	1,590	7,741,927	1,848	8,787,114
Saskatchewan								
New field wildcats	312	1,182,727	113	468,507	390	1,553,602	228	1,009,290
Other exploratory	50	179,511	28	99,203	81	255,093	241	747,363
Development	550	1,873,040	461	1,795,968	494	1,704,293	454	1,536,119
	912	3,235,278	602	2,363,678	965	3,512,988	923	3,292,773
Manitoba								
New field wildcats	59	174,313	10	30,505	21	59,503	13	33,748
Other exploratory	10	23,743	3	6,370	5	12,026	16	29,568
Development	292	647,379	54	110,073	61	142,131	37	100,003
	361	845,435	67	146,948	87	213,660	66	163,319

TABLE 7 (Cont'd)

	1955		1960		1967		1968	
	No.	Footage	No.	Footage	No.	Footage	No.	Footage
Territories								
New field wildcats	9	12,266	32	105,969	36	125,811	33	118,774
Other exploratory	–	–	–	–	4	3,133	1	736
Development	–	–	–	–	–	–	2	3,676
	9	12,266	32	105,969	40	128,944	36	123,186
Total, Western Canada								
New field wildcats	718	3,337,300	553	3,049,675	945	4,296,212	822	4,222,066
Other exploratory	167	653,215	265	1,332,401	476	2,151,365	843	3,494,811
Development	2,050	18,740,229	1,718	9,363,637	1,449	6,160,778	1,402	5,781,205
	2,935	12,730,744	2,536	13,745,713	2,870	12,608,355	3,067	13,498,082
EASTERN CANADA								
East coast-offshore								
New field wildcats	–	–	–	–	1	15,106	–	–
Ontario								
New field wildcats	64	112,246	39	68,393	50	95,824	45	82,021
Other exploratory	57	92,536	55	109,839	29	45,286	52	81,593
Development	266	271,191	213	228,190	67	78,136	79	130,642
	387	475,973	307	406,422	146	219,246	176	294,256
Quebec								
New field wildcats	9	10,226	5	4,287	–	–	1	5,990
Other exploratory	–	–	–	–	–	–	–	–
Development	–	–	1	240	–	–	–	–
	9	10,226	6	4,527	–	–	1	5,990
New Brunswick								
New field wildcats	1	3,414	2	13,023	–	–	–	–
Other exploratory	–	–	–	–	4	9,190	10	15,876
Development	7	21,143	–	–			–	–
	8	24,557	2	13,023	4	9,190	10	15,876
Nova Scotia								
New field wildcats	–	–	1	9,840	–	–	1	4,408
Other exploratory	–	–	–	–	–	–	–	–
Development	–	–	–	–	–	–	–	–
	–	–	1	9,840	–	–	1	4,408
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	51	110,930	47	92,419
Other exploratory	57	92,536	55	109,839	33	54,476	62	97,469
Development	273	292,334	214	228,430	67	78,136	79	130,642
	405	512,137	316	433,812	151	243,542	188	320,530

Table 7 (cont'd)

	1955		1960		1967		1968	
	No.	Footage	No.	Footage	No.	Footage	No.	Footage
Total, Canada								
New field wildcats	793	3,464,567	600	3,145,218	996	4,407,142	869	4,314,485
Other exploratory	224	745,751	320	1,442,240	509	2,205,841	905	3,592,280
Development	2,323	9,032,563	1,932	9,592,067	1,516	6,238,914	1,481	5,911,847
	3,340	13,242,881	2,852	14,179,525	3,021	12,851,897	3,255	13,919,612

Source: Canadian Petroleum Association.
– Nil.

TABLE 8

Canada, Wells Drilled, by Province, 1967-68

	Oil		Gas		Dry[1]		Total	
	1967	1968	1967	1968	1967	1968	1967	1968
Western Canada								
Alberta	648	556	283	395	659	897	1,590	1,848
Saskatchewan	421	387	44	47	500	489	965	923
British Columbia	50	46	43	34	93	106	186	186
Manitoba	43	28	–	–	44	38	87	66
Yukon and N.W.T.	–	2	2	2	38	32	40	36
West coast-offshore	–	–	–	–	2	8	2	8
Sub-total	1,162	1,019	372	478	1,336	1,570	2,870	3,067
Eastern Canada								
Ontario	6	9	59	61	81	106	146	176
Quebec	–	–	–	–	–	1	–	1
Atlantic Provinces	–	–	–	–	4	11	4	11
East coast-offshore	–	–	–	–	1	–	1	–
Sub-total	6	9	59	61	86	118	151	188
Canada	1,168	1,028	431	539	1,422	1,688	3,021	3,255

Source: Canadian Petroleum Association.
[1]Includes suspended wells.
–Nil.

actively being developed were the Gull Lake, Instow and Battrum fields. Oil field development in southeastern Saskatchewan, the province's main producing region, slackened to some extent as most of the fields there reached maximum development. The Freda Lake Mississippian pool was expanded and by year-end had nine producing wells. The Mississippian Tatawaga pool, discovered in 1967, has proven to be disappointing, and only one additional well has been successful.

As a secondary recovery measure, Canadian and United States operators have initiated a co-ordinated waterflood in the Flat Lake Mississippian field which straddles the Saskatchewan-Montana border. The scheme is expected to boost primary recovery by 8.2 per cent yielding an additonal 12 million barrels of oil.

Fireflooding, that is burning of oil in situ, as a method of secondary recovery has proven to be successful in the southwestern Saskatchewan heavy gravity oil fields. In this method of regulated underground combustion, the oil is heated, which lowers its viscosity and improves its ability to flow thereby permitting it to be produced. In 1965 a fireflood pilot project was installed in a large unit of the Battrum field. Since then two more fireflood pilot projects have been added to this field. In 1968, these former pilot projects were successfully expanded into full scale operations. Ultimate recovery by this method for the Battrum field is now estimated at 50 per cent of the oil in place or 157 million barrels, which is double what would normally be attained by a conventional waterflood.

Late in 1968, plans were announced to install in the Lloydminster field, a pilot secondary recovery scheme based on a combination of the in-situ combustion and waterflood techniques. This method has been used successfully in some oil fields in the United States and has tremendous potential, not only in heavy gravity fields but also as a tertiary recovery method.

BRITISH COLUMBIA

Although exploratory drilling increased by about 8 per cent, there were no significant oil discoveries made in British Columbia during 1968. In the offshore areas, Shell Canada Limited completed its 10-well drilling program. Some of the wells encountered non-commercial indications of oil and gas and confirmed the existence of a thick sedimentary section. Shell considered these factors encouraging enough to continue their drilling program into 1969. The deepest well drilled to date bottomed at 15,656 feet.

During 1968, development drilling increased by about 3 per cent. Most of the activity was confined to the Inga and Boundary Lake fields, as several infill wells were drilled. Other development drilling was conducted around the peripheries of established fields.

There were no major waterflood schemes added to existing projects this year. However, late in the year a waterflood pressure maintenance scheme was approved for the Inga field which is expected to increase the field's primary allowable from 4,200 to 7,100 barrels per day.

MANITOBA

There were few encouraging developments in Manitoba's petroleum producing industry during the year. Neither Mississippian formations, from which all of the province's production is obtained, nor other tested formations yielded significant new deposits. Minor additional reserves were added, however, to the province's reserve position by extensions to existing pools sufficient to make up for production during the year.

YUKON TERRITORY, NORTHWEST TERRITORIES AND ARCTIC ISLANDS

The recent discovery of oil at Prudhoe Bay on the north slope of Alaska has triggered a wave of activity along the Canadian Arctic continental coastline where geological conditions are somewhat similar. During the latter part of 1968, millions of acres of land were added to the imposing acreage already under permit. By year-end, two wells were being drilled in the Mackenzie River delta, one a joint venture by Imperial Oil Limited, Gulf Oil Canada Limited and Shell Canada Limited on Richards Island and the other by Imperial Oil.

Drilling decreased during the year by 4 per cent to 123,000 feet and almost all of this was in the exploratory category. Exploration was confined primarily to the southern part of the Northwest Territories in an attempt to extend the producing oil and gas trends from Alberta and British Columbia.

Two exploratory wells were drilled in the vicinity of the oil and gas discoveries made by Mobil Oil Canada, Ltd. on the Eagle Plains in 1959. Both were unsuccessful. Two wells drilled on the edge of the Norman Wells field to initiate a secondary recovery scheme were completed as oil wells.

Geological and geophysical exploration greatly increased in the territories this year as this region is rapidly developing into the industry's next major exploration frontier. A group of Calgary consulting firms have combined on two major geophysical and geological mapping programs that embrace large areas of the central Yukon and Northwest Territories. This work was done essentially for several contributing landholders but could also be sold to any other operator on request.

By the end of 1968, Panarctic Oils Ltd. had completed preliminary geological and geophysical surveys of selected areas in the Arctic Islands preparatory to selecting drilling locations. Early in 1969, the company announced the locations of the first two wells in its drilling program. Both wells will be drilled on Melville Island, the first at Drake Point and the second at Sandy Point and are scheduled to begin drilling in the spring of 1969. Panarctic is a consortium of 20 companies in partnership with the federal government, which holds a 45 per cent financial interest in the company.

EASTERN CANADA

In Ontario, total footage drilled amounted to 294,000 feet–a 34 per cent increase over 1967. Exploratory drilling constituted 55 per cent of the total and none of the wells that were drilled encountered commercial quantities of petroleum. Of the 79 development wells drilled in 1968, 51 were successful and only nine of these were completed as oil wells. The remainder were gas wells. As yet no oil discoveries have been made in Lake Erie.

A most significant feature of the exploration industry in eastern Canada during 1968 was the increasing interest shown by the major oil companies in offshore regions. This interest is evidenced by the accelerated growth in land acquisition on the continental shelf from Ungava Bay off northern Quebec to the southern tip of the Scotian Shelf bordering southern Nova Scotia. Permit acreage in these areas increased from 151 million acres in 1967 to 205 million in 1968. Several wells are scheduled to be drilled in the Atlantic offshore areas by different

TABLE 9

Oil Wells in Western Canada at End of Year 1967-68

	Producing Wells		Wells Capable of Production	
	1967	1968	1967	1968
Alberta	9,116	9,114	13,473	13,733
Saskatchewan	5,735	5,788	6,623	6,804
Manitoba	752	774	911	926
British Columbia	460	479	561	590
Northwest Territories	31	33	60	66
Total	16,094	16,188	21,628	22,119

Sources: Provincial government reports and Department of Indian Affairs and Northern Development.

companies in the next two years. One of these companies is Shell Canada Limited, which is currently having a large semi-submersible rig constructed in the Halifax shipyards to be used to evaluate its extensive offshore acreage.

In Hudson Bay, offshore permit acreage almost doubled from 54 million acres in 1967 to over 90 million in 1968. One stratigraphic test was drilled in Manitoba on the edge of the Hudson Bay Basin last year but failed to yield any indications of hydrocarbons. Late in the year a group of six oil companies announced plans to drill a joint venture well near the centre of Hudson Bay. Drilling is scheduled to begin in the summer of 1969. Together, the group of companies holds about 60 million acres of permits in Hudson Bay and has conducted extensive marine seismic programs during 1968. A specially reinforced drilling barge will be used in the operation.

TRANSPORTATION

A total of 732 miles of new crude oil and products pipeline was put into operation in 1968 as pipeline construction reached record proportions. Among the major construction projects completed was an extensive expansion program undertaken by Interprovincial Pipe Line Company to its main line on the Prairies. The third line of its system between Edmonton and Superior was brought a step nearer to completion by the installation of 182 miles of 34-inch pipe; 92 miles between Edmonton and Regina and 90 miles between Regina and Superior. All that remains to complete the third line is the construction of 170 miles of 34-inch line between Edmonton and Regina and this is scheduled for 1969. When this pipe and additional horsepower have been added, the capacity of the system from Edmonton to Regina will have been increased from 633,000 to 1,000,000 barrels per day. Lakehead Pipe Line Company, Inc., Interprovincial's United States subsidiary, completed its 464-mile 34-inch line from Superior to Griffith, Indiana. This pipeline, known sometimes as the Chicago loop will be extended from Griffith (near Chicago) to Sarnia in 1969, to take care of the growth that is anticipated in the eastern markets.

Peace River Oil Pipe Line Co. Ltd., one of 11 pipelines which connect with Interprovincial at Edmonton, completed a 297-mile 20-inch main line extension from its Valleyview pumping station north to the Rainbow-Zama oil producing region in northwestern Alberta. Peace River set the cost of delivery on the Zama to Edmonton line at 61 cents a barrel while a 66-cent tariff has been set for delivery from Zama to Edson. Capacity of the Rainbow Pipe Line Company Ltd.'s line, which also serves this producing area, was doubled to 126,000 barrels daily by the addition of new pumping capacity. In addition, Rainbow laid 59 miles of gathering line in the Rainbow and Zama fields.

TABLE 10

Mileage in Canada of Pipelines for Crude Oil, Natural Gas Liquids and Products

Year-end	Miles	Year-end	Miles
1955	5,079	1962	10,037
1956	6,051	1963	10,607
1957	6,873	1964	11,744
1958	7,148	1965	12,315
1959	7,945	1966	12,995
1960	8,435	1967	13,725
1961	9,554	1968P	14,457

Source: Dominion Bureau of Statistics.
PPreliminary.

TABLE 11

Deliveries of Crude Oil and Propane by Company and Destination, 1967-68 (millions of barrels)

Company and Destination	1967	1968
Interprovincial Pipe Line		
Western Canada	39.0	39.1
United States	77.5	99.3
Ontario	116.1	123.9
Total	232.6	262.3
Trans Mountain Oil Pipe Line		
British Columbia	31.8	33.7
State of Washington	70.2	62.6
Westridge Terminal	2.8	2.2
Total	104.8	98.5

Source: Company annual reports.

Peace River Oil Pipe Line also completed 93 miles of 20-inch loop on its main crude oil pipeline between Fox Creek and Edmonton. This parallel line will carry condensate from the Kaybob South gas plant and is the first stage of a program which will soon have the entire line looped from Valleyview to Edmonton, a distance of 170 miles.

All of the above additions serve to indicate the growing importance of northern Alberta oil.

Late in the year, 48 miles of 8-inch pipe was installed from the Chauvin heavy gravity oil producing area to Hardisty, a pumping station on the Interprovincial pipeline. In Quebec, Imperial Oil Limited completed a 62-mile products pipeline from its Montreal East refinery to Drummondville.

Near the end of 1968, Mitsue Pipeline Ltd. reduced the tariff three cents per barrel on crude oil transported in their pipeline from the Mitsue and Nipisi fields to Interprovincial's terminal at Redwater. The new rates resulted from the increased volumes of crude oil being handled by the line and are 15 cents per barrel to Redwater. Rainbow Pipe Line Company reduced the tariff on crude oil moved between the Rainbow and Zama fields and Edmonton by 5 to 7 cents per barrel. The reduction in rates is also a direct result of the increased volumes of crude oil being moved to market by this line.

PETROLEUM REFINING

Only a 1 per cent increase in Canada's crude oil refining capacity was recorded in 1969, considerably less than the demand increase for petroleum products which amounted to 7.0 per cent. Crude oil refining capacity of the 41 operating refineries totalled 1,222,150 barrels a day—an increase of 12,700 barrels a day over last year. No new refineries were built and no major additions were made to plant capacity during the year.

Projects under way but not completed include Gulf Oil Canada's 60,000-barrel-a-day refinery located at Point Tupper on Cape Breton Island. Construction has begun on this plant following the successful conclusion of financial arrangements between Gulf Oil and the federal and provincial governments as part of the federal government's plan to assist underdeveloped Cape Breton Island. In Quebec, Shell Canada Limited's expansion of its Montreal East refinery, scheduled for completion in 1968, has been delayed until 1969. Capacity is being increased from 62,000 to 110,000 barrels daily and the expansion also includes the construction of a 2,500-barrel-a-day lubricating oil plant. In Newfoundland, site preparation for a 100,000-barrel-a-day refinery to be constructed at Come-By-Chance. continued during 1968. The plant

TABLE 12

Crude Oil Refining Capacity by Regions

	1967		1968	
	Bbl/day	%	Bbl/day	%
Atlantic Provinces	128,500	10.6	128,100	10.5
Quebec	401,200	33.2	400,400	32.8
Ontario	352,400	29.1	359,100	29.4
Prairies and Northwest Territories	217,450	18.0	222,150	18.1
British Columbia	109,900	9.1	112,400	9.2
Total	1,209,450	100.0	1,222,150	100.0

Source: Department of Energy, Mines and Resources, Petroleum Refineries in Canada (Operator's List 5), January 1969.

TABLE 13

Canada, Crude Oil Received at Refineries, 1967 and 1968P
(barrels)

Location of Refineries	Year	Country of Origin						
		Canada	Middle East	Trinidad	Venezuela	Africa	USA	Total Received
Atlantic Provinces	1967	7,928	11,210,553	–	20,696,169	5,361,873	2,879,889	40,156,412
	1968P	–	8,730,047	–	31,137,702	–	–	39,867,749
Quebec	1967	–	24,653,780	5,017,837	82,122,463	8,727,545	2,033,845	122,555,470
	1968P	–	39,625,770	4,642,440	89,200,688	3,486,520	–	136,955,418
Ontario	1967	113,180,133	–	–	444,843	–	–	113,624,976
	1968P	119,890,700	–	–	469,967	–	–	120,360,667
Prairies	1967	73,344,665	–	–	–	–	–	73,344,665
	1968P	74,593,346	–	–	–	–	–	74,593,346
British Columbia	1967	37,342,177	–	–	–	–	–	37,342,177
	1968P	40,943,666	–	–	–	–	–	40,943,666
Northwest and Yukon Territories	1967	694,914	–	–	–	–	–	694,914
	1968P	750,664	–	–	–	–	–	750,664
Total	1967	224,569,817	35,864,333	5,017,837	103,263,475	14,089,418	4,913,734	387,718,614
	1968P	236,178,376	48,355,817	4,642,440	120,808,357	3,486,520	–	413,471,510

Source: Dominion Bureau of Statistics.
PPreliminary; – Nil.

TABLE 14

Regional Consumption of Petroleum Products, by Province, 1968
(thousand barrels)

	Motor Gasoline	Kerosene Stove Oil, Tractor Fuel	Diesel Fuel Oil	Light Fuel Oils Nos. 2 and 3	Heavy Fuel Oils Nos.4, 5 and 6
Newfoundland	2,126	1,423	2,476	2,087	3,377
Maritimes	9,518	3,087	4,060	9,217	14,702
Quebec	37,619	6,276	7,655	33,203	44,000
Ontario	55,671	3,358	9,151	38,085	26,072
Manitoba	7,432	1,193	2,735	1,920	848
Saskatchewan	9,933	1,305	3,867	1,413	455
Alberta	15,251	581	5,854	798	560
British Columbia	14,837	1,990	6,908	4,796	9,571
Northwest and Yukon Territories	210	64	517	255	100
Total	152,597	19,277	43,223	91,774	99,685

Source: Dominion Bureau of Statistics, Refined Petroleum Products monthly reports, 1968.

will be known as the Newfoundland Refining Company Limited and will be financed by Shaheen Natural Resources Company, a consortium of four European equipment firms and the Province of Newfoundland. Major construction is scheduled to begin in April 1969.

Having reached a nearly even balance between capacity and demand, the oil industry in Canada is beginning to embark on a new round of major refinery growth both through new plant construction and expansion of existing facilities. The bulk of the construction is scheduled for areas east of the Ottawa Vallev. Early in 1969, several large scale projects were announced, the majority of them to be located in the Province of Quebec. Golden Eagle Canada Limited plans on spending $70 million on a 100,000-barrel-a-day refinery at St. Romuald, Quebec on the south shore of the St. Lawrence River. Irving Oil Company, Limited announced that it intends to double its Saint John refinery to 100,000 barrels a day and also reaffirmed previously announced plans to build a 50,000-barrel-a-day refinery at St. Romuald. Petrofina Canada Ltd. has announced its intention to double the capacity of its 52,000-barrel-a-day Montreal East refinery. Refinery capacity in Quebec and the Atlantic provinces will thus be increased by 412,000 barrels daily in the next three years if all of these projects proceed as scheduled.

Refinery expansion in Ontario, by contrast, has lagged in recent years and present refinery capacity is being fully utilized. Rising demand for petroleum products will therefore necessitate an expansion of the province's refinery capacity. Current maximum refinery capacity in Ontario is 359,100 barrels a day with new additions expected to bring the total to only 423,000 barrels a day by 1972. A further complicating feature is that the trend in refinery production in Ontario has been to establish a yield pattern that would maximize the production of gasoline and other light ends from the crude oil input. As a consequence, the percentage yields of heavy fuel oil and other heavier products has suffered. Because of the economic advantage of producing the lighter products and the growing demand for gasoline in Ontario, this trend may be expected to be accelerated in the next few years. With a continuing strong demand for heavy fuel oil, there will likely be a continued and rapid increase in imports and transfers of heavy fuel oil into Ontario unless additional refinery capacity can be established in the immediate future. Much of the deficiency in heavy fuel oil supply in Ontario in the past has been made up from the surplus stocks of Montreal refineries which use imported crude oil for feedstock. In recent months, gasoline from Montreal refineries has also been penetrating the Ontario market causing some governmental concern.

In western Canada, Gulf Oil Canada, to achieve economies of scale, has announced its intention to construct an 80,000-barrel-a-day refinery in Edmonton. The $75 million Edmonton plant will replace an existing 14,000-barrel-a-day plant and is expected to be in operation early in 1971. In this connection, Gulf's 3,600-barrel-a-day Brandon, Manitoba plant is to be closed in April 1969 and modification of operations at its other Prairie refineries are being considered.

Imperial Oil Enterprises Ltd. remained the largest refiner in Canada. The company's nine refineries comprise 33 per cent of Canadian refinery capacity. Gulf Oil Canada Limited's nine plants constitute 15.8

per cent of the country's capacity. Shell Canada Limited, third largest refiner, operates six plants which account for 15.2 per cent of the total.

MARKETING AND TRADE

Crude oil consumption by Canadian refineries totalled 1,133,000 barrels a day in 1968, or 7.0 per cent more than in 1967. Domestic crude made up 57.2 per cent of the total crude received at refineries, about 5 per cent more than the daily average in 1967. Most of the demand increase for domestic production by Canadian refineries occurred in Ontario and British Columbia. Refinery receipts of domestic crude oil in Ontario amounted to 120 million barrels–more than half of all the domestic crude oil consumed in Canada and 6 per cent greater than last year's consumption. British Columbia's consumption of domestic crude oil rose 10 per cent to 41 million barrels whereas there was a negligible increase in Prairie consumption.

Imports of crude oil averaged 487,000 barrels a day in 1968, up 9 per cent from 1967. Venezuela continued to be the major supplier of imported crude oil, increasing its exports to Canada by 17 per cent to an average daily total of 330,000 barrels. Middle East exports also appreciably increased. At 132,000 barrels a day, they were 35 per cent higher than last year's daily average. However, shipments from this area have still not reached the level they had attained prior to the Arab-Israeli conflict in 1967. The prolonged closure of the Suez Canal has delayed the return to normal marketing patterns as the world's tankers still have to traverse the longer route around the southern tip of Africa to meet the requirements of consuming countries. The Middle East sources for Canadian use were Iran, Saudi Arabia, Iraq, Kuwait and the Trucial States. The continuing civil strife in Nigeria contributed to a further reduction in that country's former substantial exports to Canada such that 9,600 barrels daily were imported in comparison to 24,000 barrels daily in 1967. By early 1969 many of the country's oil fields had been returned to near normal operating conditions and it is expected that production should reach a higher level by mid-year.

Imports of refined petroleum products increased by 7 per cent to 200,000 barrels a day in 1968. The bulk of the product imports came from Venezuela and

TABLE 15

Imports of Refined Petroleum Products 1967-68
(millions of barrels)

	1967	1968p
Heavy fuel oil	37.04	32.29
Light fuel oil	9.49	13.77
Stove oil	2.89	3.94
Motor gasoline	4.14	4.16
Aviation gasoline	0.36	0.13
Diesel fuel	4.65	6.07
Lubricating oil	1.63	1.66
Petroleum coke	2.71	2.69

Source: Dominion Bureau of Statistics.
1968 figures are totals of monthly imports from Refined Petroleum Products.
pPreliminary.

TABLE 16

Supply and Demand of Oils, 1967-68
(thousand barrels)

	1967r	1968p
SUPPLY		
Production		
Crude oil and condensate	351,292	379,387
Other natural gas liquids	53,356	58,613
Net production	404,648	438,000
Imports		
Crude oil	163,149	177,739
Products	68,205	73,716
Total imports	231,354	251,455
Change in stocks		
Crude and natural gas liquids	−5,343	−6,773
Refined petroleum products	+ 937	−4,283
Total change	−4,406	−11,056
Oils not accounted for	+1,415	+3,375
Total supply	633,011	681,774
DEMAND		
Exports		
Crude oil	150,345	167,488
Products	15,192	18,128
Total	165,537	185,616
Domestic sales		
Motor gasoline	142,795	151,984
Middle distillates	155,569	164,599
Heavy fuel oil	91,097	97,796
Other products	46,403	47,050
Total	435,864	461,429
Uses and losses		
Refining	29,799	32,151
Field, plant and pipeline	1,811	2,578
Total	31,610	34,729
Total demand	633,011	681,774

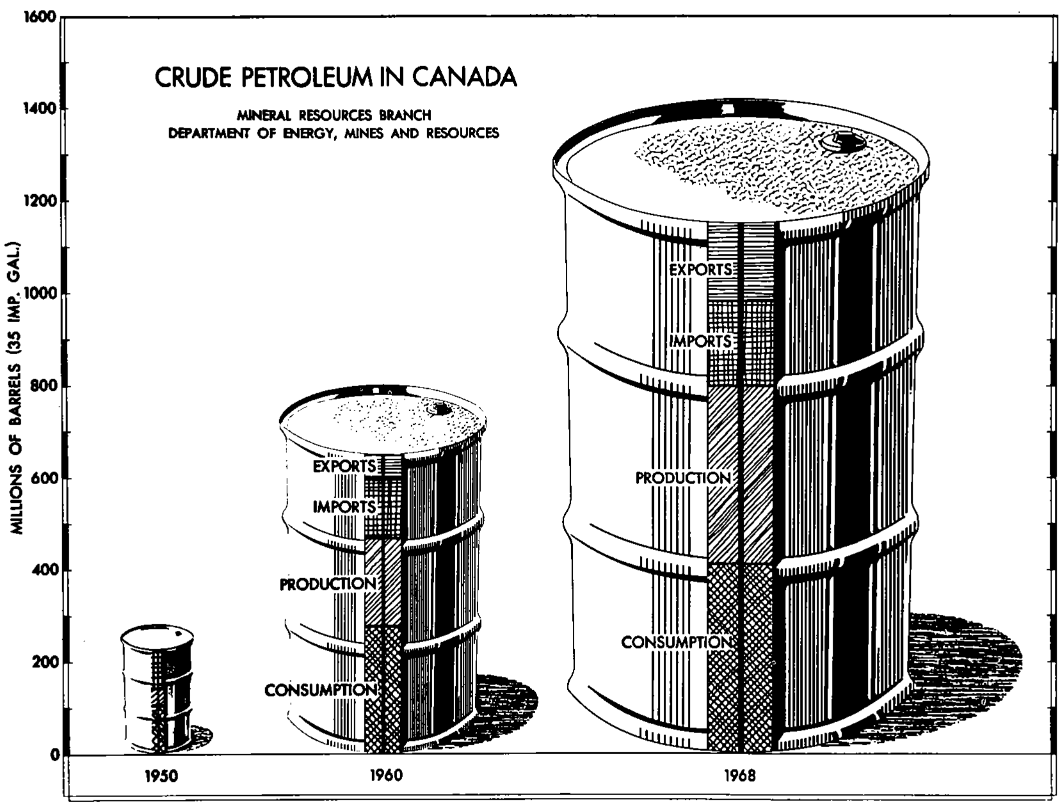
Source: Dominion Bureau of Statistics and Provincial government reports.
rRevised; pPreliminary.

the Netherland Antilles and consisted mainly of fuel oil and diesel fuel. Most of these products were absorbed in Quebec and the Atlantic provinces although demand in Ontario increased sharply during the past year and caused some movement of foreign oil into this region.

Demand for Canadian crude oil in the United States increased to 460,000 barrels a day, a gain of about 11 per cent over 1967. Canadian exports to the United States west coast region via Trans Mountain Oil Pipe Line Company averaged 172,000 barrels a day, a drop of 20,000 barrels daily from the 1967 daily average of 192,000 barrels. Most of this decrease can be attributed to the return to normal marketing patterns in the Pacific northwest region where shortages were created in 1967 by the Middle East crisis. The expected large increases in shipments of Alaskan crude oil to the United States west coast area did not materialize in 1968 and had very little impact on imported Canadian crude oil to that area.

Average daily shipments to the United States mid-continent by Interprovincial Pipe Line Company increased by 28 per cent to nearly 272,000 barrels a day in 1968. Exports of crude oil to the eastern Rocky Mountain area via the Rangeland-Glacier pipeline system approximated 20,000 barrels a day during the year. Although Canadian crude oil entering the United States is not subject to formal controls of their Mandatory Oil Imports Program, the rapid increase in Canadian exports to the United States has been cause for concern to some sectors of the United States producing industry. In recent years the Great Lakes region of the United States has experienced increasingly large seasonal demands for oil and their domestic industry, largely because of pipeline deficiencies, has been unable to meet these increased requirements. Consequently, the refineries in this area have found it necessary at these times to call on Canada for increased amounts of oil. Nevertheless, in an effort to maintain harmonious relations, government authorities successfully called for the co-operation of the industry to reduce the rate of growth for crude oil exports to United States markets east of the Rockies. In essence, the voluntary restrictions asked companies to limit exports to this area to 280,000 barrels a day in 1968. In the ensuing period 1969-71, imports are not expected to exceed a yearly increment of 26,000 barrels a day.

Exports of petroleum products increased by 20 per cent to 50,000 barrels a day. Most of the exported products, mainly butane, propane, heavy fuel oil and gasoline, were shipped to the United States but approximately 6,000 barrels a day of propane were shipped to Japan.

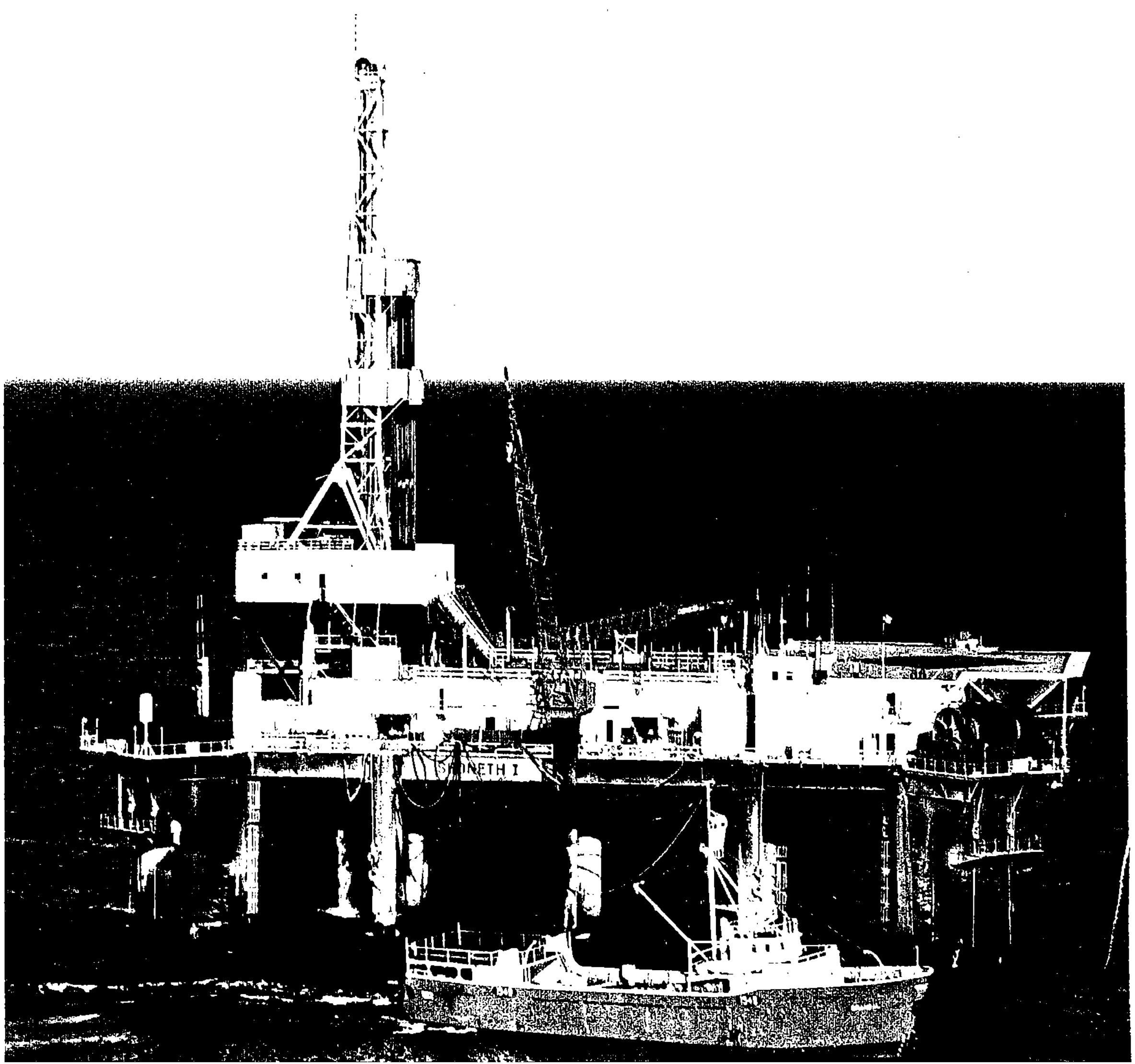


OUTLOOK

The decline in the productive capabilities of the United States petroleum producing industry combined with a burgeoning growth in the country's demand for petroleum products, ensures that the outlook for the long term growth in exports for Canadian crude oil is excellent. However, the continuing trend towards significant increases in Canadian crude oil reserves, accompanied by the immediate problem of finding adequate markets to maintain production at economic levels has tended to contribute to a rather uncertain short term outlook.

The discovery of major reserves of crude oil on the Arctic coast of Alaska has had a twofold effect on Canada's oil industry—one detrimental, the other favourable. On one hand, it has tended to slow down the development of the immense reserves of the Athabasca tar sands and Cold Lake heavy oil by creating an air of uncertainty regarding future export market outlets for such production, while on the other hand it has accelerated the exploration of Canadian arctic coastal areas. Industry activity in this remote area is therefore expected to intensify during the coming year. Exploratory and development activity is also expected to continue near current levels in the traditional inland areas and increase in offshore areas. Drilling off Canada's west coast will continue and drilling will resume off Canada's Atlantic seaboard and probably in Hudson Bay. If the anticipated major reserves of crude oil are discovered in any of these remote exploration areas, the future pattern of crude oil marketing could be considerably altered.

View of Sedneth I drilling vessel off east coast of Nova Scotia engaged in a drilling program for Shell Canada. (Photo courtesy Shell Oil Canada)



Phosphate

W. E. KOEPKE*

Canada imports phosphate rock for use in manufacturing agricultural and industrial phosphate products sold in domestic and export markets. There is no production of phosphate rock in Canada. United States is the chief supplier of phosphate rock and is Canada's largest export market for finished phosphate. The principal phosphate products are elemental phosphorus and phosphate fertilizers. About four fifths of the world's phosphate rock consumption is for agricultural purposes.

Demand for phospate fertilizers in North America increased at unprecedented rates from 1960 to 1967 and production expanded accordingly, but in 1968 demand weakened and the prospects are for further weakening in 1969. Fertilizer stockpiles were large at the end of 1967 and widespread inclement weather in the spring seeding season contributed to a large carry-over of fertilizer into the summer and fall of 1968. A weakening of farm incomes and large wheat inventories are other reasons for the curtailment of sales. In Canada, fertilizer manufacturers in the Prairie Provinces were affected most and as a result production was temporarily suspended at two phosphate plants, one at Regina, Saskatchewan, and one at Winnipeg, Manitoba. Phosphate fertilizer sales in eastern Canada were at nearly the same level in 1968 as in 1967 but there was an oversupply of phosphate materials and as a result, one plant at Welland was temporarily closed after the 1968 spring seeding season.

A new elemental phosphorus plant–the second in Canada–was brought into production late in 1968 at Long Harbour, Placentia Bay, Newfoundland.

PHOSPHATE ROCK

Phosphate is a term used to describe 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 followed by apatite, which can be represented by the formula $Ca_5(PO_4)_3(F, Cl, OH)$. The term phosphate rock, in general usage, includes apatite. 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, and thermal treatment whithout 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

*Mineral Resources Branch.

TABLE 1

Canada, Phosphate Rock Imports and Consumption, 1967-68

	1967		1968P	
	Short Tons	$	Short Tons	$
Imports				
United States	2,146,596	18,435,000	2,345,513	18,603,000
Netherlands Antilles	7,864	317,000	4,467	196,000
Morocco	125,307	1,811,000	–	–
Total	2,279,767	20,563,000	2,349,980	18,799,000
	1966		1967	
Consumption (available data)				
Fertilizers, stock and poultry feed	1,546,834		2,070,776	
Chemicals	185,830		201,442	
Other*	2,824		2,877	
Total	1,735,488		2,275,095	

Source: Dominion Bureau of Statistics.
* Includes amounts for refractories, food processing, medicinals and pharmaceuticals.
P Preliminary; – Nil.

TABLE 2

Canada, Phosphate Rock Imports and Consumption, 1959-68
(short tons)

	Imports	Consumption
1959	797,063	786,044
1960	941,998	891,894
1961	1,056,885	976,639
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
1968P	2,349,980	..

Source: Dominion Bureau of Statistics.
P Preliminary; .. Not available.

eastern Ontario and southwestern Quebec; apatite deposits of some carbonate alkaline complexes in Ontario and Quebec; and sedimentary phosphate rock deposits of late Palaeozoic – 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 Lievre 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. The Nemegos deposits have been examined extensively during the past few years by Multi-Minerals Limited and have been the basis for hydrochloric acid-leach feasibility studies carried out by a West German company, Klockner-Humboldt-Deutz A. G.

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.

IMPORTS AND CONSUMPTION

Canada's phosphate rock imports in 1968 were 2.35 million tons, up slightly from 1967. An estimated 60 per cent came from Florida with most of the remainder from the western states (Idaho, Montana, Utah and Wyoming). In recent years, the sedimentary phosphate rock fields in Florida and the western states had supplied approximately–equal proportions of Canada's pnosphate rock imports from United States, the former supplying rock to markets in eastern

Canada and the latter supplying rock to manufacturers in western Canada. In 1965 a system was inaugurated whereby Florida rock is shipped to Vancouver by water and then inland to Alberta by rail and potash is back-hauled from Saskatchewan. Incoming Florida rock shipments through Vancouver amounted to 382,000 tons in 1968, more than double that in 1967.

There were no imports of phosphate rock from Morocco in 1968, apparently because of the closure in 1967 of one plant and the change of ownership early in 1968 of another, both of which had been using North African rock.

WORLD PRODUCTION

World production of phosphate rock reached 82 million metric tons in 1968, a 7.7 per cent increase from 1967. The increase was considerably larger than the previous year but well below the average annual growth rate of 12 per cent that was experienced from 1960 to 1966. World phosphate rock inventories were high at the end of 1968 and only moderate increases in output are expected in 1969.

TABLE 3

World Production of Phosphate Rock, 1967-68
('000 metric tons)

	1967	1968p
U.S.A.	36,079	37,500
USSR	15,593	17,250
Morocco	9,922	
Tunisia	2,810	14,500
Algeria	180	
Togo	1,139	2,500
Senegal	1,266	
South Africa	1,352	
Rhodesia	71	1,670
Uganda	11	
Egypt	699	
Jordan	894	2,560
Israel	609	
Nauru, Ocean Island	2,247	3,815
Christmas Island	1,091	
Others	2,049	2,100
Total	76,012	81,895

Source: The Journal of World Phosphorus and Potassium.
p Preliminary.

CANADIAN PHOSPHATE INDUSTRY

ELEMENTAL PHOSPHORUS

Elemental phosphorus is produced in Canada by the thermal reduction method. Thermal reduction involves the smelting of phosphate rock with carbon (coke) and a siliceous flux; co-products of the process are ferro-phosphorus, carbon monoxide and calcium silicate slag. About 9 tons of phosphate rock grading 66-68 per cent BPL are required to manufacture one ton of phosphorus. Although elemental phosphorus can be used for making fertilizers, it is generally used in the manufacture of chemicals, insecticides, detergents and other industrial compounds.

Electric Reduction Company of Canada, Ltd. (ERCO) uses this process, employing electric furnaces at Varennes, Quebec, and a newly-opened plant at Long Harbour, Newfoundland. Annual capacities are 20,000 tons of elemental phosphorus for the Varennes plant and 80,000 tons for the Long Harbour plant. The first of two electric furnaces at ERCO's new $40-million plant at Long Harbour, came on stream in December 1968 and the second was scheduled to begin operation early in 1969.

About 60 per cent of the phosphorus output from the Long Harbour plant is intended for export markets and the remainder is to be shipped to ERCO's plants in Buckingham, Quebec, and Port Maitland, Ontario. Much of the export shipments will be carried in two specially built 5,000-ton vessels to ERCO's parent firm, Albright & Wilson Ltd., in England.

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 important. Nitric acid is used in some countries and hydrochloric acid processes have received considerable attention during the past few years.

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 one ton of superphosphate, grading 20 per cent P_2O_5 equivalent, are 0.64 tons of phosphate rock (70-72 per cent BPL) and 0.47 ton of sulphuric acid (100 per cent basis). There are four plants in Canada with a combined yearly capacity of about 380,000 tons of single superphosphate (Table 4).

To produce phosphoric acid, larger quantities of sulphuric acid are added to maintain a fluidic 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

TABLE 4

Canada, Phosphate Fertilizer Plants, 1968

Company	Plant Location	Acidulation Capacity tpy P_2O_5 eq.	Principal End-Products	Basis for H_2SO_4
Belledune Fertilizer Limited	Belledune, N.B.	90,000	am ph	SO_2 smelter gas
Border Fertilizer Ltd.	Winnipeg, Man.*	16,000	am ph	sulphur
Canadian Industries Limited	Beloeil, Que.	28,000	s s	sulphur
	Hamilton, Ont.	28,000	s s	sulphur
	Courtright, Ont.	80,000	am ph	SO_2 pyrrhotite
Cominco Ltd.	Regina, Sask.*	. .	am ph	. .
	Kimberley, B.C.	128,000	am ph	SO_2 pyrrhotite
	Trail, B.C.	86,000	am ph	SO_2 smelter gas
Cyanamid of Canada Limited	Welland, Ont.*	13,000	t s, am ph	sulphur
Electric Reduction Company of Canada, Ltd.	Port Maitland, Ont.	190,000	H_3PO_4, s s, t s, ca ph	SO_2 smelter gas and sulphur
Green Valley Fertilizer & Chemical Co. Ltd.	North Surrey, B.C. (near Vancouver)	1,000	s s	SO_2 smelter gas
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		886,000		

*Production was suspended in 1968 because of poor marketing conditions.
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.

acid. Typical raw material requirements for one 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), which is equivalent to 0.86 ton of sulphur. 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), 11-48-0 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.

Canada has ten producers of phosphoric acid with a combined yearly capacity of about 775,000 tons of P_2O_5 equivalent (Table 4). An eleventh plant, scheduled to come on stream in mid-1969, is being built at Redwater, Alberta, about 35 miles northeast of Edmonton, by Imperial Oil Limited. The $50-million complex will include the following plants: sulphuric acid, phosphoric acid – ammonium phosphate, ammonia, nitric acid, ammonium nitrate and urea. The complex is designed to produce 500,000 tons of fertilizers annually.

TABLE 5

Canada, Phosphate Fertilizer Production, Years Ended June 30, 1959-68
(short tons P_2O_5 equivalent)

1959	175,000
1960	199,570
1961	231,840
1962	261,033
1963	299,453
1964	353,547
1965	374,159
1966	461,608
1967	533,460
1968	538,796

Source: Dominion Bureau of Statistics.

PRODUCTION, TRADE AND CONSUMPTION

Production of phosphate fertilizers in Canada in the fertilizer year 1967/68 (twelve months ended June 30, 1968) was 538,796 tons of P_2O_5 equivalent, up 1.0 per cent from the previous twelve months but far below the average annual growth rate of 15 per cent experienced between 1959/60 and 1966/67. In general, there was an oversupply of fertilizers on the North American market in the spring of 1968 resulting in the temporary closure of three phosphate plants in Canada during the year. The three plants were: Cyanamid of Canada Limited at Welland, Ontario; Cominco Ltd. at Regina, Saskatchewan; and Border Fertilizer Ltd. at Winnipeg, Manitoba.

Nearly all Canada's trade in phosphate fertilizers is with United States, mostly in areas where plants are close to farming communities in the neighbouring country. Occasional export shipments, frequently of the foreign aid type, go to southeast Asian countries. Exports of phosphate fertilizers in the fertilizer year 1967/68 reached a record high of 165,048 tons of P_2O_5 equivalent, up 19 per cent from the previous year. Imports in 1967/68 amounted to 43,726 tons of P_2O_5 equivalent, down 41 per cent from the previous twelve months and were at the lowest level since about 1950.

Sales of phosphate fertilizers for consumption in Canada in the fertilizer year 1967/68 were 440,093 tons of P_2O_5 equivalent, up 6.8 per cent from the previous twelve months but far below the average annual growth rate of 15 per cent experienced between 1959/60 and 1966/67. The slackening of sales in eastern Canada in 1968 was largely a result of unfavourable wet weather that caused delay in the spring seeding season and in western Canada, it stemmed from a combination of inclement weather and weakening of farm incomes arising from the difficulties in selling wheat. Phosphate fertilizer sales

TABLE 6

World Production of Phosphate Fertilizers, 1966/67 and 1967/68[1]
('000 metric tons P_2O_5 equivalent)

	1966/67	1967/68[p]
U.S.A.	4,697	4,868
USSR[2]	1,776	1,867
France[3]	1,333	1,420
Australia	970	982
West Germany	861	834
Japan	639	693
Italy	516	553
Canada	484	489
Belgium	425	467
Britain[4]	403	430
Others	4,596	4,997
World Total	16,600	17,600

Sources: United Nations FAO, Mon. Bull. Agr. Econ. Stat., Feb. 1969, and Dominion Bureau of Statistics.

[1] Fertilizer year July 1 to June 30; [2] Calendar year referring to first part of split year; [3] Fertilizer year May 1 to April 30; [4] Fertilizer year June 1 to May 30. [p] Preliminary.

TABLE 7

Canada, Trade in Selected Phosphate Products, 1967-68

	1967		1968^p	
	Short Tons	$	Short Tons	$
Imports				
Calcium phosphate				
United States	18,718	1,860,000	18,199	1,816,000
Japan	955	69,000	1,605	105,000
Belgium and Luxembourg	1,300	85,000	500	24,000
Total	20,973	2,014,000	20,304	1,945,000
Fertilizers				
Normal superphosphate				
United States	35,492	810,000	14,395	384,000
Triple superphosphate				
United States	46,821	2,638,000	30,205	1,565,000
Chemicals				
Potassium phosphates				
United States	1,676	465,000	1,447	448,000
Sodium phosphate, tribasic				
United States	969	171,000	839	143,000
France	–	–	83	7,000
Total	969	171,000	922	150,000
Sodium phosphates, n.e.s.				
United States	8,855	1,640,000	6,173	1,246,000
West Germany	33	8,000	28	9,000
Total	8,888	1,648,000	6,201	1,255,000
Exports				
Nitrogen phosphate fertilizers				
United States		26,596,000		24,397,000
India		–		1,368,000
Total		26,596,000		25,765,000

Source: Dominion Bureau of Statistics.
^{p}Preliminary; – Nil; n.e.s. not elsewhere specified.

in the Prairie Provinces, had increased at an average annual rate of 25 per cent from 1959/60 to 1966/67 and by 11 per cent in 1967/68. Sales of phosphate fertilizers in the Prairie Provinces in 1967/68 were 246,659 tons of P_2O_5 equivalent and in Ontario and Quebec 159,894 tons.

CANADIAN INDUSTRY OUTLOOK

The long-term prospects for Canada's phosphate industry are favourable although for 1969 the outlook is poor. Except for the lack of a domestic source of phosphate rock, the Canadian industry is in a particularly favourable position insofar as raw materials are concerned. Rock is readily available from foreign suppliers at competitive prices. Sulphur is in adequate supply in Canada. Natural gas, which is the key raw material used to manufacture ammonia in North America for the preparation ammonium phosphate fertilizers, is in abundant supply. Electrical power, necessary for the manufacture of elemental phosphorus, is relatively cheap and plentiful from hydroelectric plants.

In 1969, output of both elemental phosphorus and phosphate fertilizers will likely fall well short of total plant capacities. At the newly-opened plant at Long Harbour, Newfoundland, production of elemental

TABLE 8

Canada, Phosphate Fertilizer Consumption and Trade, Years Ended June 30, 1959-68
(short tons P_2O_5 equivalent)

	Consumption	Imports*	Exports
1959	144,876	44,103	87,957
1960	153,243	45,040	98,318
1961	177,132	46,188	100,166
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

Source: Dominion Bureau of Statistics.
*Excludes nutrient content of mixtures.

phosphorus was temporarily suspended early in May 1969 because of pollution of fishing waters in Placentia Bay. In western Canada, where two phosphate fertilizer plants were already shut down in 1968, output was reportedly suspended in May 1969 at a third plant at Fort Saskatchewan, Alberta. Others are believed to have cut back their production schedules. In spite of these cut backs, a new plant scheduled to come on stream at Redwater, Alberta, in mid-1969, will add to the capacity for fertilizer production in western Canada. Fertilizer sales in the Prairie Provinces in 1969 could be as much as 20 per cent below the 1968 level. Moderate increases in sales to farmers in eastern Canada are expected for 1969.

PRICES AND TARIFFS

Phosphate rock prices are based upon the BPL content. Maximum limits of moisture, iron and alumina are specified. 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 available phosphoric acid (a.p.a.).

The December 30, 1968, issue of *Oil, Paint and Drug Reporter* listed the following prices:

Phosphate rock, Florida land pebble, run-of-mine, washed, dried, unground, bulk, carlots, f.o.b. mines, per short ton:

66-68 per cent BPL	$6.50
68-70	7.50
70-72	8.15
74-75	9.20
76-77	10.20

Defluorinated phosphate, feed grade, paper bags, carlots (some truckloads), various U.S. points, 18 per cent P, per short ton: $65.25-$91.00

Phosphoric acid, agricultural, grade, f.o.b. Occidental, Fla., per unit-ton, 52-54 per cent a.p.a. $1.37

Superphosphate, run-of-pile, pulverized, bulk, carlots, f.o.b. works, per unit-ton, under 22 per cent a.p.a. $0.92-$1.10

The price listing for phosphate rock remained unchanged from the previous two years, but phosphoric acid prices were slightly higher.

Phosphate rock and phosphate fertilizer materials enter Canada and United States duty free.

Platinum Metals

A.F. KILLIN*

Canada is the world's third largest producer of the platinum group metals (platinoids). The USSR is the world's largest producer followed by Republic of South Africa, Canada, United States and Colombia in that order. In Canada the platinoids – platinum, palladium, rhodium, ruthenium, iridium and osmium – are recovered as byproducts from the refining of nickel-copper ores and the volume of recovery varies with the production of these ores. Canadian production in 1968 was 464,400 troy ounces valued at $44,025,124; an increase of 63,137 ounces and $9,356,209 from 1967.

The United States Bureau of Mines estimated world production in 1968 at 3,384,440 troy ounces; 232,013 ounces more than in 1967. Production statistics are not available for the USSR but the United States Bureau estimated Russian production at 59 per cent of the world total. The Republic of South Africa produced 850,000 ounces in 1968, United States 40,000 ounces and Colombia 20,000 ounces. There was minor production from Japan and Ethiopia.

Non-communist world production was not sufficient to supply the demand for platinum metals and additional metal was purchased from metal dealers and from the USSR. The dual pricing formula, consisting of a producers price quoted by Engelhard Industries, Inc. and Johnson, Matthey & Co., Limited and a free market price quoted by merchant dealers and the agents selling for the USSR, persisted throughout 1968. Most of the platinoids produced in the non-communist world were sold at the producers price. Metal reclaimed from scrap and the Russian metal were sold at the free market price.

*Mineral Resources Branch.

PRODUCTION

CANADIAN

Canadian nickel-copper ores, principally from the Sudbury area of Ontario, contain most of the platinum metals recovered in Canada. The grade has been estimated at 0.025 troy ounce 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 the nickel-copper sulphide matte from the nickel smelting process. Nickel-copper anodes are purified by electrolysis and the precious metals released are collected from the electrolytic tanks as sludge. This sludge is purified, then shipped to refineries in Britain and the United States for the recovery of the individual platinum metals. Nickel ores containing platinum metals are mined in Ontario, Quebec, Manitoba and British Columbia. No precious metals are recovered in Canada from the British Columbia ores because the concentrates are sold to Japan.

Consolidated Canadian Faraday Limited at Gordon Lake, Ontario, shipped nickel-copper concentrates to The International Nickel Company of Canada, Limited (Inco) at Sudbury for treatment. Faraday was developing the Bird River, Manitoba mine of Maskwa Nickel Chrome Mines Limited for production in 1969. Two mines in Quebec, Marbridge Mines Limited at Malartic and Lorraine Mining Company Limited at Belleterre, shipped nickel-copper concentrates to Sudbury for treatment. Both of these mines were closed in 1968.

TABLE 1

Canada – Platinum Metals – Production and Trade, 1967-68

	1967		1968p	
	Troy Ounces	$	Troy Ounces	$
Production[1]				
Platinum, palladium, rhodium, ruthenium, iridium	401,263	34,668,915	464,400	44,025,124
Exports				
Platinum metal in ores and concentrates				
Britain	447,130	27,487,000	547,174	35,539,000
United States	20	2,000	12,526	527,000
Norway	9,948	955,000	9,716	933,000
Total	457,098	28,444,000	569,416	36,999,000
Platinum metals				
United States	1,237	156,000	14,671	911,000
Britain	17,497	1,226,000	537	91,000
Switzerland	–	–	195	54,000
Other countries	23	3,000	123	13,000
Total	18,757	1,385,000	15,526	1,069,000
Platinum metals in scrap				
Japan	4,000	188,000	10,975	1,030,000
Britain	6,982	864,000	10,550	1,150,000
United States	15,355	1,523,000	10,516	716,000
Other countries	60	14,000	–	–
Total	26,397	2,589,000	32,041	2,896,000
Re-Exports[2]				
Platinum metals, refined and semiprocessed	164,033	9,087,955	83,228	8,254,753
Imports				
Platinum lumps, ingots, powder and sponge				
Britain	14,184	1,761,000	22,544	3,137,000
United States	2,266	295,000	1,759	280,000
Netherlands	–	–	6	1,000
Belgium and Luxembourg	4	1,000	–	–
Total	16,454	2,057,000	24,309	3,418,000
Other platinum group metals in lumps, ingots, powder and sponge				
Britain	188,639	10,730,000	176,082	13,273,000
United States	6,755	331,000	7,204	371,000
France	–	–	366	15,000
Belgium and Luxembourg	1,041	43,000	–	–
Total	196,435	11,104,000	183,652	13,659,000

TABLE 1 (Cont'd)

	1967		1968p	
	Troy Ounces	$	Troy Ounces	$
Total platinum and platinum group metals				
Britain	202,823	12,491,000	198,626	16,410,000
United States	9,021	626,000	8,963	651,000
France	–	–	366	15,000
Netherlands	–	–	6	1,000
Belgium and Luxembourg	1,045	44,000	–	–
Total	212,889	13,161,000	207,961	17,077,000
Platinum crucibles				
United States	15,450	1,702,000	15,607	1,719,000
Platinum metals, fabricated materials, n.e.s.				
United States	9,274	517,000	14,480	802,000
Britain	11,050	1,166,000	2,847	343,000
Republic of South Africa	–	–	7	1,000
Total	20,324	1,683,000	17,334	1,146,000

Source: Dominion Bureau of Statistics.
[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.
pPreliminary; – Nil; n.e.s. Not elsewhere specified.

TABLE 2

World Production of Platinum – Group Metals
(troy ounces)

	1966	1967p	1968e
USSR	1,800,000	1,900,000	2,000,000
Republic of South Africa	783,400	828,400	850,000
Canada	396,059	401,263	464,440
United States	51,432	16,365	40,000
Other countries	8,558	6,399	30,000
Total	3,039,449	3,152,427	3,384,440

Source: U.S. Bureau of Mines, Minerals Yearbook, 1967 and Commodity Data Summaries, January 1969.
pPreliminary; eEstimated.

In the Sudbury area, Inco operated 12 mines, four mills and two smelters for the treatment of platinoid-bearing nickel-copper ores. Nickel-copper matte from the Sudbury smelters was refined at the company refinery at Port Colborne, Ontario and the precious metal sludges shipped to the company refinery at Acton, England for refining. Inco was developing four new mines in the Sudbury area and a fifth mine at Shebandowan for production by 1971. Falconbridge Nickel Mines, Limited operated eight mines, four mills and a smelter. Nickel-copper matte from the Falconbridge smelter was shipped to the company refinery at Christiansand, Norway for refining. Precious metal sludges were shipped to the United States for refining.

FOREIGN

SOUTH AFRICA

Rustenburg Platinum Mines Limited, the non-communist world's largest platinum producer, continued the expansion of production facilities that started in 1951. In 1967 production capacity was estimated at 1,190,000 ounces of platinum metals, this was expanded to 1,350,000 ounces in 1968 and will be further expanded to an estimated 1,585,000 ounces by 1973. The smelter in South Africa, jointly owned by Rustenburg and Johnson, Matthey & Co. South Africa (Pty) Limited was expanded in 1968 and a further expansion is planned to treat the increased mine output. The Johnson, Matthey refinery at Wadeville was scheduled for completion in 1969. The refinery will treat a portion of the matte from the smelter. Union Corporation, a South African investment firm, was preparing a mine for production near Rustenburg. Initial output will be about 150,000 ounces of platinum metals. The company will build a refinery to process the metals in South Africa. Anglo-Transvaal Consolidated Investment Company, Limited has applied for a mining permit to develop a mine on the Middlepunt farm in the Lyndenburg District of the Transvaal. Initial production is scheduled at 15,000 ounces a year by late 1969.

USSR

Platinoids in the USSR were derived mainly from the mining of deposits in the nickel-bearing basic and ultra-basic rocks of the Norilsk region of Siberia. Small amounts of placer platinum were recovered from the southern Urals. Russian production in 1968 was estimated by the US Bureau of Mines at 2 million ounces.

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

The 20,000 ounces of platinum metals produced in Colombia were recovered from placer deposits in the Choco district.

USES

Platinum metals are valuable to industry because of their many special properties, the chief of which are catalytic activity, resistance to corrosion, resistance to oxidation at elevated temperatures, high melting points, high strength and high ductility. Platinum and palladium are the principal platinum metals. Iridium, osmium, ruthenium and rhodium are used mainly as alloying elements to modify properties of platinum and palladium. Rhodium is used in plating.

The catalytic action of platinum, palladium, rhodium and ruthenium is utilized in the oil 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 salts and complexes as homogeneous catalysts for the oxidation, isomerisation, hydrogenation and polymerisation of olefins.

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 for the production of glass, rayon

TABLE 3

Platinum Metals – Production and Trade, 1959-68

	Production[1]			Exports		Imports[4]
	Platinum (troy oz)	Other Platinum Metals (troy oz)	Total (troy oz)	Domestic[2] $	Re-exports[3] $	$
1959	150,382	177,713	328,095	12,497,221	8,676,998	6,466,280
1960	..	..	483,604	16,068,728	8,404,563	12,951,420
1961	..	..	418,278	26,331,101	9,820,374	11,242,328
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[R]	11,779,822	14,930,000
1967	..	..	401,263	29,829,000	9,087,955	13,161,000
1968[p]	..	..	464,400	37,768,000	8,254,753	17,077,000

Source: Dominion Bureau of Statistics.
[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.
[p]Preliminary; . . Not available for publication. [R] Revised.

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.

OUTLOOK

The major consumption increase since World War II has been in the uses of platinum. Some increased use has been recorded for the other platinoids, particularly palladium, but the present and future growth will be for platinum. The future growth in platinum consumption will depend on the stability of supplies, the success of research to promote new uses and the ability of industry to find suitable substitutes or to develop more efficient methods that could reduce the quantities of platinum consumed in its established uses.

In the non-communist world, demand will probably exceed supply for the next two years. Beyond this time it is possible that more efficient catalysts used for the production of high octane fuels will reduce the quantity of platinum required by the oil industry, however, any decline in consumption could be partly offset by increases in refinery capacity. A significant possibility is a ban on the use of anti-knock additives in gasoline in order to reduce air pollution. If the more industrialized nations imposed such a ban, there would be a sharp increase in the consumption of platinum in catalysts because of the necessity for the production of fuels with higher octane ratings.

PRICES

Prices of the platinum metals varied during the year. The following table summarizes the price changes in the United States as quoted by *Metals Week:*

TABLE 4

Prices of Platinum Metals, 1968

	$/troy ounce
Iridium	
January 1 to December 31	185–190
Dealers*	190–195
Osmium (nominal)	
January 1 to December 31	300–450
Palladium	
January 1 to February 7	37–39
February 8 to March 18	39–41
March 19 to July 6	42–44
Palladium (Cont'd)	
July 7 to December 31	45–47
Dealers*	46–48
Platinum	
January 1 to January 14	109
January 15 to July 6	109–114
July 7 to December 31	120–125
Dealers*	253–257
Rhodium	
January 1 to December 31	245–250
Dealers*	252–255
Ruthenium	
January 1 to December 31	55–60
Dealers*	45

Source: *Metals Week.*
*Yearly average.

TARIFFS

	Most Favoured Nation†
CANADA	
Platinum wire, bars, strips, sheets, plates; platinum, palladium, iridium, osmium, ruthenium and rhodium in lumps, ingots, powder, sponge, scrap	free
Crucibles of platinum, rhodium and iridium and covers therefore	free
UNITED STATES	
Platinum metals, unwrought not less than 90% platinum	free
Other platinum metals including alloys of platinum	32%
Platinum metal, semi-manufactured, gold-plated	40%
Platinum metal, semi-manufactured, silver-plated	19%
Other semi-manufactured platinum including alloys of platinum	32%
Products, no dimension under 0.125 incl., wholly of metals of the platinum group separately, wholly of native combinations of metals of the platinum group or artificial combinations containing by weight not less than 90% of the metal platinum.	free

Sources: The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa.
Tariff Schedules of the United States, Annotated (1969) TC Publication 272.
†On and after January 1, 1969

Potash

W.E. KOEPKE*

World consumption of potash continued to rise in 1968 but for the third consecutive year, supply outpaced demand and prices remained weak. Demand for potash was strong in parts of Europe but potash fertilizer sales in North America were sluggish and only increased marginally over 1967, largely because of adverse weather conditions and weak farm-product prices. Producer stocks of potash were unusually high at the beginning of 1968 and remained high at the end of the year.

Reflecting low prices, the value of Canada's potash shipments in 1968 (preliminary figure) averaged \$25.58 a ton of K_2O equivalent compared with \$28.28 in 1967, \$31.49 in 1966, and \$37.53 in 1965. The highly competitive marketing conditions caused some of Canada's potash companies to scale down their production schedules, and shipments for the year were somewhat lower than anticipated. Production and exports nevertheless were considerably higher than in 1967 and Canada gained greater prominence as the world's largest exporter of potash. During 1968 in Saskatchewan, four mines were in production throughout the year and one was being expanded; three new mines were brought on stream; construction of the eighth and ninth mines was nearing completion for start-up in the first half of 1969; and construction of a tenth mine was under way with production scheduled to begin in 1971.

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 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 normally 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. Fertilizer grades produced in Canada normally range from an accepted minimum of 60 per cent up to 63 per cent K_2O equivalent. Pure potassium chloride contains 52.4 per cent potassium (K).

PRODUCTION AND DEVELOPMENTS IN CANADA

Production (shipments) of potash in Canada rose sharply to 2.9 million tons of K_2O equivalent in 1968, a 21 per cent increase from 1967. Total value was \$74 million, an increase of 9.8 per cent from 1967.

*Mineral Resources Branch.

DEPOSITS AND OCCURRENCES

Underground potash deposits occur in the prairie provinces of Manitoba, Saskatchewan, and Alberta, and in the Malagash-Wallace area of Cumberland County, Nova Scotia. Only those in Saskatchewan have attained commercial importance. The deposits in Nova Scotia 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. Traces of potash minerals were discovered in southwestern Newfoundland while exploring for salt in the summer of 1968; they occur in the same evaporite sequence as the deposits in Nova Scotia.

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

TABLE 1

Canada, Potash Production and Trade, 1967-68

	1967		1968p	
	Short Tons	$	Short Tons	$
Production (shipments) K_2O equivalent	2,383,253	67,395,461	2,890,733	73,950,000
Imports – Fertilizer potash				
Potassium chloride				
West Germany	13,434	351,000	13,761	328,000
United States	6,969	199,000	10,185	205,000
Britain	13	2,000	2	–
France	7,004	165,000	–	–
Total	27,420	717,000	23,948	533,000
Potassium sulphate				
United States	21,736	828,000	23,844	828,000
Italy	3,638	188,000	1,100	54,000
France	4,700	147,000	–	–
West Germany	200	8,000	–	–
Total	30,274	1,171,000	24,944	882,000
Potash fertilizer, not elsewhere specified				
United States	21,442	357,000	20,133	378,000
Total, potash fertilizer	79,136	2,245,000	69,025	1,793,000
Potash chemicals				
Potassium carbonate	693	127,000	755	144,000
Potassium hydroxide	1,685	336,000	1,914	375,000
Potassium nitrate	1,699	215,000	2,669	310,000
Potassium phosphates	1,676	465,000	1,447	448,000
Potassium bitartrate	156	94,000	164	97,000
Potassium silicates	1,100	194,000	1,167	207,000
Total potash chemicals	7,009r	1,431,000r	8,116	1,581,000
Exports – Fertilizer potash				
Potassium chloride (muriate of potash)				
United States	. .	58,923,000	. .	62,936,000
Japan	. .	10,060,000	. .	12,440,000
Netherlands*	. .	9,165,000	. .	10,856,000
New Zealand	. .	1,655,000	. .	2,613,000
India	. .	3,320,000	. .	1,561,000
South Korea	. .	854,000	. .	1,412,000
Brazil	. .	215,000	. .	803,000
Taiwan	. .	709,000	. .	786,000
Other countries	. .	1,242,000	. .	2,749,000
Total	. .	86,143,000	. .	96,156,000

Source: Dominion Bureau of Statistics.

*All or nearly all was trans-shipped to Britain.

pPreliminary; – Nil; rRevised; . . Not available.

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 are as much as 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 ($KCl.MgCl_2 6H_2O$) whereas in other areas this mineral is generally lacking but 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 shaft for hoisting. Normally there is some underground primary crushing.

In the surface plant, the rock is further crushed and the sylvite is separated out 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 deep 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 1968, there were 38 potash disposition holders in Saskatchewan with 911,862 acres under lease, 99,840 acres pending lease, and 2,394,548 acres under permit. The amount under permit is down 1,659,615 acres from that held a year earlier.

Exploration and development work carried out during the past few years have been greatest in three regions of Area No. 1; Saskatoon-Lanigan, Esterhazy-Yorkton, and Regina-Duval. At the end of 1968, seven mines were operating–four in the Saskatoon-Lanigan region, two at Esterhazy, and one near Regina. Six are conventional shaft mines and one is a solution mine. Annual productive capacity of all seven mines is 8.45 million tons of potash product (KCl), but because of the current oversupply of potash on world markets some of the mines are being operated at reduced rates. Expansions and new mines scheduled for completion in 1969 and on through to the end of 1971 will bring Saskatchewan's annual productive capacity to 11.5 million and 12.5 million tons of potash product, respectively.

TABLE 2

Canada, Potash Production and Trade,
Years Ended June 30, 1959-68
(short tons K_2O equivalent)

Year Ended June 30	Production	Imports*	Exports
1959	. .	91,794	. .
1960	. .	85,820	. .
1961	–	101,370	. .
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

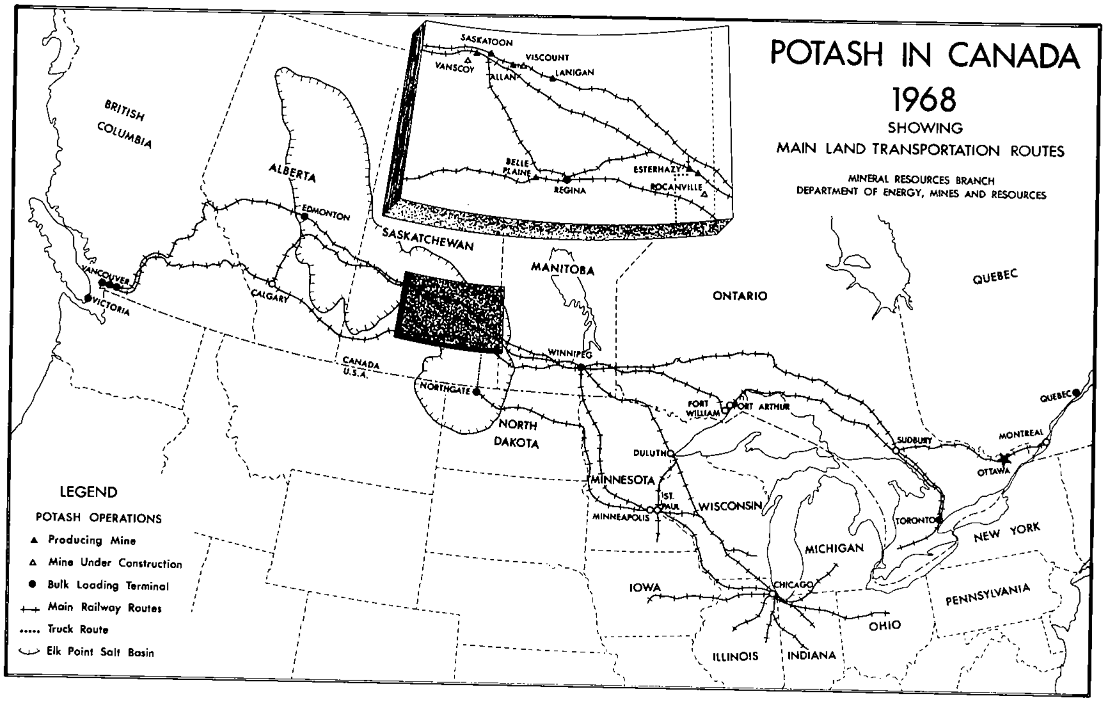
Source: Dominion Bureau of Statistics.
*Includes potassium chloride, potassium sulphate and sulphate of potash magnesia, except that contained in mixed fertilizers.
– Nil; . . Not available.

TABLE 3

Canada, Summary of Potash Mines, 1968

Company	Location*	Initial Production (scheduled)	Capacity Million stpy** KCl	Capacity Million stpy** K_2O eq.	Remarks
Producers					
IMC, K-1	Esterhazy	1962	2.00	1.20	One 16-ft shaft; mining 7.5-ft bed at 3,148 feet.
K-2	Esterhazy	1967	1.50	0.90	One 18.5-ft shaft; mining 8-ft bed at 3,150 feet. K-1 and K-2, located 6 miles apart, are connected underground.
Kalium	Belle Plaine	1964	0.75	0.45	Solution mining from beds about 5,200 feet deep. Plant being expanded.
PCA	Saskatoon	1965	0.70	0.42	One 16-ft shaft; mining 10-ft bed at 3,315 feet. A second shaft, 3,000 feet distant, is being sunk.
Allan	Allan	1968	1.50	0.90	Two 16-ft shafts; mining 10-ft bed at 3,409 feet.
Alwinsal	Lanigan	1968	1.00	0.60	One 18-ft shaft; mining 11-ft bed at 3,280 feet.
Duval	Saskatoon	1968	1.00	0.60	Two 16-ft shafts; mining 10-ft bed at 3,315 feet.
Sub-total			8.45	5.07	
Prospective Producers					
Cominco	Vanscoy	(1969)	1.20	0.72	One 18.5-ft shaft and one 16-ft shaft; to mine 10-ft bed at 3,532 feet.
Noranda	Viscount	(1969)	1.50	0.90	Sinking two 16-ft shafts; will mine 10-ft bed at about 3,350 feet.
Sylvite	Rocanville	(1971)	1.00	0.60	Sinking two 16-ft shafts to a depth of about 3,300 feet.
Sub-total			3.70	2.22	
Grand Total			12.15	7.29	

*All in the Province of Saskatchewan; **Calculations based on conversion factor of 0.60 K_2O equivalent equals 1.0 KCl.



International Minerals & Chemical Corporation (Canada) Limited (IMC) is the largest potash producer in Canada. IMC has two mines, K-1 and K-2, near Esterhazy, each with a single shaft and refinery; they are connected underground at the potash mining horizon. In June 1968, IMC cut back production appreciably and laid off part of its work force.

Kalium Chemicals Limited operates the only commercial potash solution mine in the world. Kalium's mine at Belle Plaine, about 20 miles west of Regina, began operating in 1964 with a designed capacity of 600,000 tons of potash product annually. Output during 1967 and 1968 is believed to have reached a level of 750,000 tons annually. In 1968, Kalium was in the process of spending $10 million to modify facilities and expand its productive capacity by 50 per cent; completion is expected in 1969.

Potash Company of America (PCA), a division of Ideal Basic Industries, Inc., was the first to mine potash in Canada. PCA's mine, about 14 miles east of Saskatoon, began operating in 1958 but was forced to close down a year later because of water seepage into the shaft; it was reopened in 1965 and has subsequently operated at capacity. In December 1968, PCA reached the potash beds at a second shaft that is expected to be completed to a depth of 3,500 feet in February 1969; cost of the second shaft was estimated at $12 million. Although the second shaft will initially serve to improve mine ventilation and supply, it is designed with a hoisting capacity that will allow expansion to 3 million tons of product annually. PCA added a compaction unit to its plant in 1968 to increase the output of coarse and granular grades.

Allan Potash Mines brought its $80 million potash mine at Allan, about 40 miles east of Saskatoon, on stream in May 1968. The mine has two shafts, 500 feet apart, completed to depths of 3,585 and 3,685 feet. Designed productive capacity of the mine and refinery is 1.5 million tons of potash product annually, but because of the oversupply situation, Allan Potash has kept its output rate somewhat lower by shutting down periodically. Allan Potash Mines is a joint venture financed by United States Borax & Chemical Corporation, Homestake Mining Company, and Swift Canadian Co., Limited. The interests of United States Borax and Homestake are combined in a 50-50 partnership called Can-Am Potash Producers Ltd., which owns 80 per cent of Allan Potash Mines and acts as sales agent for the partners. The remaining 20 per cent interest is held by Swift Canadian, a wholly-owned subsidiary of Swift & Company.

Alwinsal Potash of Canada Limited officially opened in October 1968 its $60 million Sarcee potash mine, near Lanigan, about 70 miles east of Saskatoon. The mine, with one shaft completed to a depth of 3,290 feet, and refinery have a productive capacity of 1.0

million tons of potash product annually. A second shaft may be sunk later. Alwinsal is a consortium of West European potash producers. A 50 per cent interest is held by Mines de Potasse d'Alsace and the remaining 50 per cent is shared equally by Wintershall A.G. and Salzdetfurth A.G. Potash sales are handled by Potash Company of Canada Limited, a subsidiary of Alwinsal.

Duval Corporation of Canada began trial runs in the refinery in mid-1968 and at year-end was in the final stages of start-up of its $63 million potash mine, located 6 miles west of Saskatoon. The mine has two shafts, 850 feet apart, bottomed at depths of 3,492 and 3,549 feet. Designed productive capacity of the mine and refinery is 1.0 million tons of potash product annually, but Duval plans to operate at a lower rate until marketing conditions improve. Duval Corporation of Canada, formerly known as Duval Corporation, is a subsidiary of Pennzoil United, Inc.

Cominco Ltd. began trial runs in the refinery in the summer of 1968 and at year-end was nearing start-up of its $65 million potash mine near Vanscoy, 20 miles southwest of Saskatoon. It was officially opened in January 1969. The production and service shaft is completed to a depth of 3,750 feet and the downcast ventilation shaft, 500 feet away, is 3,575 feet deep. Although the mine and refinery have been designed to produce 1.2 million tons of potash product annually, the company has indicated that it will operate at a lower rate until marketing conditions improve.

Noranda Mines Limited is developing an $86 million potash mine at Viscount, 45 miles east of Saskatoon. High-pressure water zones and flows into the shaft area caused some difficulty early in 1968 but shaft-sinking has proceeded without undue delay and the potash beds were reached in October at a depth of about 3,350 feet. The company is sinking twin shafts 440 feet apart. Refinery construction is proceeding on schedule. Production from the 1.5 million-ton-a-year mine is expected to begin in June 1969. Noranda's mine will be operated under the name, Central Canada Potash Limited.

Sylvite of Canada Ltd. is spending an estimated $70 million to develop a potash mine near Rocanville, about 25 miles southeast of Esterhazy. Twin shafts, 500 feet apart, are being sunk to a depth of about 3,300 feet. The mine and refinery will have an annual capacity of 1.0 million tons of potash product and is scheduled to begin production in January 1971. Hudson Bay Mining and Smelting Co., Limited increased its interest in Sylvite of Canada Ltd. from 51 per cent to full ownership in December 1968.

In addition to producing mines and projects under construction, several other companies have been engaged in exploration and in conducting mine feasibility studies. Among them are Scurry-Rainbow Oil Limited, Canberra Oil Company Ltd., Kerr-McGee Corporation, Lynbar Mining Corporation Limited, and Southwest Potash Corporation. Although there had been some indications a year or two ago that one or possibly more of these companies would proceed with mine development, oversupply of world potash and weak prices have contributed to delaying further mine construction in Saskatchewan in 1968.

On December 30, 1967, the Province of Saskatchewan approved an amendment to the subsurface mineral regulations that allows the lessee of Crown potash lands to obtain an extension on his lease by payment of $90,000 annually to the province. The amendment enables the lessee to retain his lease and protect his exploration investment without a large expenditure should he prefer to postpone mine development.

In May 1968, the Province of Nova Scotia announced that it would provide $75,000, along with $300,000 from the Atlantic Development Board, to assist private enterprise to further explore the potash deposits in Cumberland County. Terms of the offer specified that private enterprise would have to match the expenditure. No acceptable proposals had apparently been received by the end of 1968.

CANADIAN CONSUMPTION AND TRADE

Canada exports over 90 per cent of its potash output. Exports in 1968, amounted to $96 million compared with $86 million in 1967. In 1968, approximately 1,980,000 tons of K_2O equivalent, representing about 68 per cent of Canada's potash output, went to the United States. Japan was the next largest customer, followed by Britain which is served indirectly through terminal and warehousing facilities at Rotterdam, Netherlands.

Almost all of Canada's overseas potash sales, together with a substantial portion to southeastern United States, are channelled through the Vancouver port area, some 1,100 railway miles from the potash mines. In 1968, the three bulk-loading terminals—Vancouver Wharves Ltd., Pacific Coast Bulk Terminals Ltd., and Neptune Terminals Ltd.—in the Vancouver area handled 1.66 million tons of potash product for export markets. The three terminals collectively provide storage for 350,000 tons of potash product and a loading capacity of about 11,000 tons per hour. Deep-sea berthing facilities at these terminals can accommodate vessels up to 65,000 dead-weight tons.

Canadian potash shipments to central and midwestern United States have been transported directly by rail from the mine to distributor. In November 1968, IMC inaugurated a system of trucking potash from Esterhazy to a newly-built railway loading terminal just south of the International Boundary, a distance of about 150 miles. The truck-railway system may handle as much as 1 million tons of product annually.

TABLE 4

Canada, Available Data on Potash Consumption, 1966-67
(short tons)

	1966	1967
Potassium chloride		
Fertilizers and chemicals	202,721	192,446
Other*	2,126	2,211
Total	204,847	194,657
Potassium sulphate		
Fertilizers	24,000[e]	26,000[e]
Potassium magnesium sulphate		
Fertilizers	15,000[e]	20,000[e]
Potassium nitrate		
Mixed fertilizer	500[e]	500[e]

Source: Dominion Bureau of Statistics.
*Cleaners, soaps, gypsum products, medicinals and miscellaneous minor uses.
[e]Estimated.

TABLE 5

Canada, Consumption of Potash Fertilizers, Years Ended June 30, 1959-68
(short tons K_2O equivalent)

Year Ended June 30	In Materials	In Mixtures	Total
1959	4,443	83,631	88,074
1960	4,387	84,888	89,275
1961	5,404	96,514	101,918
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

Source: Dominion Bureau of Statistics.

About three quarters of Canada's domestic potash shipments are carried by railway to fertilizer distributors in southern Ontario and Quebec. Consumption of potash fertilizers in Canada, in the fertilizer year 1967/68 (twelve months ended June 30, 1968) was 183,100 tons of K_2O equivalent, up 2.8 per cent from the previous twelve months but the increase was considerably lower than the average annual growth rate of 10.8 per cent experienced for the previous five-year period.

WORLD REVIEW

About 95 per cent of the world's potash consumption is as fertilizer, the balance being used in a host of industrial applications. From 1950 to 1964, world potash output exceeded potash fertilizer consumption by an average of 6 per cent. Over the same period, potash production and consumption experienced an average annual growth rate of 7 per cent but then the growth rates increased sharply with consumption moving up to 10 per cent annually from 1965 to 1967. Production increased even more and by 1967 potash output exceeded potash fertilizer consumption by about 13 per cent. Potash prices began to weaken in 1966 and the trend has continued.

Some producers cut back their 1968 production schedules and world output for the year rose only 2 per cent to 15.6 million metric tons of K_2O equivalent. World consumption in 1968 was an estimated 14.1 million metric tons for potash fertilizers and 700,000 metric tons for non-agricultural purposes, giving an overall consumption increase of 8 per cent from 1967. Demand was strong in most European countries, whereas in North America consumption increased slightly to about 4 million metric tons in 1968, up 2 per cent from the previous year. In 1968, North American potash prices were at the lowest level on record.

TABLE 6

World Potash Production, 1967-68
('000 metric tons K_2O equivalent)

Country	1967	1968[p]
USSR	2,868	3,150
Canada	2,162	2,622
United States	2,993	2,469
Germany, West	2,131	2,220
East	2,206	2,200
France	1,818	1,719
Spain	571	592
Israel	300	310
Italy	245	266
Chile (nitrate)	15[e]	15[e]
Total	15,309	15,563

Source: U.S. Bureau of Mines and Dominion Bureau of Statistics.
[p]Preliminary; [e]Estimated.

USSR

USSR continued an upward trend in potash production in 1968 and displaced the United States as the world's leading potash producer. Deposits occur in three widely separated areas of USSR: near Solikamsk and Berezniki on the west side of the northern Ural

Mountains, some 120 miles north of Perm; near Kalusz and Stebnik in the Carpathian Mountains of Ukrainian SSR; and near Soligorsk, some 75 miles south of Minsk, Byelorussia (White Russian SSR). In 1968, output from two Combines in the northern Urals, Solikamsk No. 1 and Berezniki No. 1, is believed to have been 3.4 million metric tons of potash products, averaging 41.6 per cent K_2O equivalent. A second Combine at Berezniki is expected to begin production in 1969 and a third was reported to be under construction. In the Soligorsk area, output from two Combines is believed to have reached 3.5 million metric tons of potash products in 1968 and a third Combine was scheduled to begin production in 1969. Annual output from the mines in the Carpathian Mountains is about 200,000 metric tons of potash product. The USSR's aim for 1972 is to double potash output from the 1967 level.

UNITED STATES

Potash production in the United States decreased 18 per cent in 1968 from the previous year and was 543,000 metric tons less than its record output in 1966. In the Carlsbad area, New Mexico, some operations that were shut down in the last half of 1967 remained closed in 1968 with the exception of one that had been owned by United States Borax & Chemical Corporation; it was sold to Continental American Royalty Co. in August 1968 and reactivated by a subsidiary, United States Potash & Chemical Co. Potash output increased moderately in California and at Moab, Utah, Texas Gulf Sulphur Company increased production by 20 per cent from 1967. Of the United States' total potash output, the proportion produced at Carlsbad declined from 89 per cent in 1966 to 84 per cent in 1968 and the trend is expected to continue. Late in 1968, Great Salt Lake Minerals & Chemicals, a joint venture financed by Gulf Resources & Chemical Corporation and Salzdetfurth A.G. of West Germany, announced plans for the construction of a chloride-sulphate complex to be based on brines from Great Salt Lake, Utah; the complex, scheduled for completion in 1970, will include a 240,000-ton-a-year potassium sulphate plant. Also at Great Salt Lake, a similar complex is planned by National Lead Company and Hogle-Kearns Co.

EAST GERMANY

In East Germany, where potash production had increased considerably from 1965 to 1967, output remained at about the same in 1968. Moderate increases are expected in 1969 and 1970 followed by a substantial increase in 1971 when production starts from a new potash deposit near Magdeburg, some 85 miles north of Erfurt, the latter being the centre of the East German potash industry. The new Combine is reportedly designed to mine 24,000 tons of potash rock daily, almost equal to one quarter of East Germany's current mining rate. Poland is apparently supplying a substantial part of the construction services and equipment for the Combine in return for potash shipments.

WEST GERMANY

West Germany's potash production rose slightly from its 1967 level to reach 2.2 million metric tons in 1968 but remained below that country's record output of 2.39 million metric tons in 1965. Widespread changes have been introduced to the West German potash industry during the past few years in order to remain competitive with other world producers. New machinery and equipment have been installed, particularly in the underground workings, thereby reducing the labour force and yet maintaining the same production rate and some mines have been closed. Refining techniques are being improved and natural gas fuel is now being used at some plants for firing the boilers and dryers. West German potash output is expected to remain fairly steady during the next few years.

FRANCE

Potash output in France amounted to about 1.7 million metric tons in 1968, down considerably from a record production of 1.88 million metric tons in 1965 and the lowest level in five years. The lower output was largely a result of industrial unrest and production stoppages during the year. The state-owned holding organization, Enterprise Minière et Chimique and its operating subsidiary, Mines de Potasse d'Alsace, have been reorganizing and modernizing the potash industry in order to stabilize output. Part of the program involves the closure of some mines and in other cases, the addition of new machinery and equipment. Production is expected to be about 1.7 million metric tons of K_2O equivalent in 1969 and that level is likely to be maintained throughout the early 1970's.

OTHERS

In Spain, potash production increased considerably in 1968 and further increases are expected in 1969 and 1970. Potash production in Israel increased moderately in 1968 but large increases are expected as the only potash producer, Dead Sea Works, Ltd. plans to increase annual output to the million-ton mark by the early 1970's. Output from Italy's potash industry has remained fairly steady during the last three years and plans to expand operations have apparently not materialized.

Potash deposits are about to be exploited in a number of other countries. Compagnie des Potasses du Congo is spending $82 million US to develop an underground potash deposit near Saint Paul, Republic of Congo (Brazzaville), some 30 miles inland from the port at Pointe Noire. Part of the expenditure is for improved railway facilities and a new wharf and terminal at Pointe Noire. The mine is designed for an annual output of 500,000 metric tons of K_2O equivalent and is scheduled to begin operation in 1969. Elsewhere in Africa, exploratory and preliminary development work have been conducted on deposits in the Danakil Depression of Ethiopia and in Morocco.

Construction is about to begin on England's first potash mine and there are plans for two more. Cleveland Potash Ltd. a joint venture financed by Charter Consolidated Ltd. and Imperial Chemical Industries Ltd., has gained the approval of local authorities to proceed with construction of a $60 million US potash mine near Staithes, Yorkshire, on the northeast coast of England. Completion is scheduled for 1973 with full annual production of 1.0 million tons of potash products to be reached in 1974; Britain will then be self-sufficient in potash. Plans for a second mine were announced in late 1968 by Yorkshire Potash Limited, a subsidiary of The Rio Tinto-Zinc Corporation Limited. The proposed mine is to be located near Hawkser, about 8 miles from Cleveland Potash's site, and will likely produce 1.0 million tons of potash products annually beginning in 1973 or 1974. A third company, Whitby Potash Ltd., a subsidiary of Armour & Company, is also seeking permission to establish a potash solution-mine in the same area. The Yorkshire potash deposits are at a depth of 3,200 to 4,000 feet and grade 26 to 30 per cent K_2O equivalent.

In Australia, plans have apparently been finalized by Texada Mines Pty. Ltd. to proceed with development of a salt-potash project at Lake McLeod, a few miles inland from Cape Cuvier, Western Australia. Salt production was scheduled to begin early in 1969 with potash to follow in the 1970's.

In South America, feasibility studies and negotiations are continuing in the hope of producing phosphate rock and potash in the Sechura Desert of northern Peru. The potash is contained in near-surface brines.

OUTLOOK

The long-term outlook for the world potash industry is favourable but the prospects for 1969 through to 1971 are poor. A four-man potash committee, which was appointed by the Province of Saskatchewan, reported its findings in July 1968 and predicted that there would be excess world potash productive capacity until 1977 and that excess North American potash productive capacity would reach a maximum during 1970 and 1971. Its findings for the world industry were based on a projected growth rate of 7 per cent annually for potash consumption.

World potash production is expected to increase considerably in 1969 and inventories could reach their highest peak in history. This over-supply condition will be more critical in North America where fertilizer sales have been sluggish in both 1967 and 1968 and are threatening to remain weak in 1969. Production cutbacks were exercised by some North American producers late in 1967 and in 1968 but even greater restraint will likely be required.

Canada had sufficient mine capacity at the end of 1968 to supply over one third of the world's potash consumption and two more mines are scheduled to begin operation in 1969. Unfortunately market conditions in 1969 will not permit the industry in Saskatchewan to operate at capacity, nevertheless, Canada is expected to become the world's leading potash producer in 1969 followed by USSR.

PRICES

Potash prices for the period July 1, 1968 to December 31, 1968, were listed by producers in Canada as follows:

Muriate of Potash, bulk, carload lots, f.o.b. mine, per unit (20 lbs) K_2O

	60% K_2O Min.	62% K_2O Min.
Standard	31.3¢	31.9¢ to 33.5¢
Coarse	35.6¢	36.2¢
Granular	37.8¢	38.3¢

Storage allowances of $3.24 to $3.25 a ton were to be deducted for shipments from July 1 to September 30, 1968, and $1.94 to $2.00 a ton from October 1 to December 31, 1968.

TARIFFS

	British Preferential	Most Favoured Nation	General
CANADA			
Potash, muriate and sulphate of, crude; nitrate of potash	free	free	free
German potash salts and German mineral potash	free	free	free
Potash, chlorate of, not further prepared than ground	free	15%	20%
UNITED STATES			
Potassium chloride or muriate of potash		free	
Potassium sulphate		free	
Potassium nitrate		free	

The United States Bureau of Customs published withholding of appraisement notices, dated June 11, 1968, directing its customs officers to withhold appraisement of potassium chloride, otherwise known as muriate of potash, imported from Canada, West Germany, and France. Since then, exporters from these three countries have had to post bonds on potash shipments into United States. The directive was issued on the basis of preliminary findings in an investigation that was launched August 8, 1967, under the Antidumping Act.

Rare Earths

W.H. JACKSON*

The basis of the rare earth industry is a series of metals comprising scandium (element 21), yttrium (element 39) and the lanthanide series (elements 57 to 71); all of these are in Group III B of the periodic table.

These elements have an abundance in igneous rocks of 153 parts per million. In relation to one another they have a relative abundance as follows, in per cent: lanthanum 11.93; cerium 30.05; praseodymium 3.60; neodymium 15.58; promethium (not measurable); samarium 4.22; europium 0.69; gadolinium 4.15; terbium 0.59; dysprosium 2.91; holmium 0.75; erbium 1.61; thulium 0.13; ytterbium 1.73; lutetium 0.49; yttrium 18.31; and scandium 3.26.

On this basis, cerium is more abundant than tin or cobalt and thulium is more abundant than silver. The rare earths are chemically similar to one another and deposits of the individual rare earths do not result from geological processes.

Yttrium group or cerium group (elements 57 to 63) rare earths will predominate in a particular mineral but all will be present. In general, granitic rocks are more favourable for the concentration of yttrium group rare earths; the alkalic rocks and carbonatites tend to concentrate the cerium group. A number of rare earths have a low abundance and a corresponding distribution in mineral deposits. Accordingly, commercial deposits do not contain rare earths in the same proportions as required by market demand with the result that some rare earth products are readily available at low cost; others, particularly high purity separated compounds are available at higher cost, and, for some compounds, no significant market has yet developed. The problem has been to find and develop sources of supply to meet changing industrial requirements.

A substantial increase in demand for products of the rare earth industry occurred in the last five years. 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 suppliers dependent upon the market for phosphors, particularly those containing yttrium, were faced with diminishing markets.

In the same period, lower priced products showed a marked increase in demand such as 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 markets in the future.

CANADIAN INDUSTRY

Uranium mines in the Elliot Lake district of Ontario became, in the last three years, the major source of yttrium-bearing concentrate in the world. All rare earths, except promethium have been detected in these ores which contain uraninite, uranothorite, 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. Under current

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conditions of supply and demand, the yttrium oxide content is the only constituent of value.

Denison Mines Limited was the only producer of rare earth concentrate in 1968. Rio Algom Mines Limited phased-out production of thorium and the rare earths at its Nordic mill at the end of 1967. The mill was subsequently closed and uranium treatment was continued at the Quirke Lake mill.

Shipments of rare earth concentrate in 1968 were 111,326 pounds containing Y_2O_3 valued at $934,986. As yttrium was in oversupply during 1968, these shipments were less than those recorded for 1967 (172,551 pounds valued at $1,594,298).

WORLD INDUSTRY

The minerals monazite and bastnasite are the main sources of cerium group 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. Small parcels from a number of other countries do not add materially to supply. Brazil and India process monazite domestically and do not export concentrates. As monazite of placer origin is relatively low cost, lode deposits are currently uneconomic.

The mine of Molybdenum Corporation of America, at Mountain Pass, California is the main source of concentrates for cerium group rare earths and, unlike monazite, concentrates from the unusual carbonatite deposit do not contain thorium. The ore, mined by 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.

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 USSR. 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 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. The latter, in re-opening the Port Pirie uranium extraction plant, may recover scandium oxide among other possible products. 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 are occasionally available such as euxenite, samarskite, fergusonite, etc. but they are difficult to treat and markets are limited for these yttrium group rare earths.

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, Santohu Metal Industry Company; in India, Indian Rare Earths Limited; in Brazil, Commissao National de Energia Nuclear (Industrias Quimicas Reunidas). Production in the USSR is state controlled and output is sold through Techsnabexport.

USES

Rare earth oxides, products of chemical extraction, are mainly used as mixtures in about the same proportions as they occur in concentrates. Mixtures are used in glass-polishing compounds, for the production of mischmetal, and as alloying agents in nodular iron, steel, and magnesium. Mischmetal has a stable use in lighter flints. For catalysts in petroleum refining more refined rare earth chlorides of lanthanum, neodymium and praseodymium are in increasing demand as their use increases the value of petroleum distillation by yielding a higher proportion of gasoline.

The main metallurgical uses are those involving cerium in the preparation of nodular iron, and yttrium and neodymium as hardeners in magnesium alloys. Samarium and yttrium alloyed with cobalt have potential as permanent magnets. High purities are not required. Gadolinium and europium are used in control rods in nuclear reactors. Artificial garnets containing yttrium and gadolinium are used in microwave devices.

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 ultra-violet rays in bottles by additions of cerium and praseodymium to coloured glass. Praseodymium imparts a yellow-green, 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.

The main demand in the electronics industry is for high-purity red phosphors for use in colour television tubes. Technical improvements led to a decrease in consumption to 5 grams per tube. Brighter phosphors have been developed such as europium activitated yttrium oxysulphide. Gadolinium oxide activated with europium is under development.

PRICES

Metals Week in February 1969 quoted a nominal value of $180 a long ton for monazite sand, c.i.f. United States ports. Unleached bastnasite concentrates, f.o.b. California, were quoted at 30 cents a pound for material grading 55 to 60 per cent rare earth oxide. Leached concentrate sells for 35 cents a pound for a grade of 68 to 72 per cent. Calcined oxide from this source assaying 88 to 92 per cent rare earth oxide was quoted at 45 cents a pound.

Xenotime concentrates grading about 25 per cent Y_2O_3 are estimated to be worth $3 U.S. per pound of contained Y_2O_3.

The grade of concentrates originating from Canada is not published. Sales made in 1968 had a value of $8.39 Canadian per pound contained Y_2O_3. All concentrates are best sold on a contract basis and odd lots may be difficult to sell.

In the United States, the average value of refined products was $1.50 per pound in 1968. Specific products have a wide range in price depending upon purity, grades and demand. Typical prices of rare earth products are quoted in the *American Metal Market.* Examples of prices follow to illustrate the range. Metallurgical or glass grades of cerium oxide are available at 40 cents a pound. Other grades range up to $9.50 a pound. Yttrium oxide, phosphor grade, is worth $38 and europium oxide $525, samarium oxide $40, lanthanum oxide $4.50, lanthanum hydrate 50 cents, neodymium oxide $40 and praseodymium $50. Mischmetal sells for $3 a pound, yttrium metal for $160, europium $3,600.

Roofing Granules

H.S. WILSON*

The consumption of roofing granules in Canada reached a record high volume of 169,685 tons in 1968. The previous record high volume of 147,877 tons was achieved in 1955. The consumption in 1968 increased 16.4 per cent over that of 1967. The value increased 11.9 per cent comparing 1968 to 1967.

Table 1 shows the consumption of granules in 1967 and 1968 by type, and colour and whether domestically-produced or imported.

Table 2 shows granule consumption from 1958 to 1968, the total annual values and the percentages of granules consumed that were produced in Canada. These latter figures are broken down into the naturally-coloured and artificially-coloured types as well as the total consumed. This table shows a general, cyclical increase in consumption since 1958. It also indicates the considerable increase of the share of the market achieved by the Canadian-produced granules, over the past 11 years.

Table 3 shows the average prices of naturally- and artificially-coloured granules, both domestic and imported, for 1967 and 1968. In all tables, the prices are f.o.b. consuming plants.

CANADIAN PRODUCERS

The manufacturers of roofing granules in Canada are located at Ville Jacques Cartier, Que., Havelock and St. Davids, Ont. and Vancouver, B.C.

Industrial Granules Ltd., of Ville Jacques Cartier, the producer of a black slag granule, obtains raw materials, waste slag, from steam-generating plants at Halifax, N.S. and Concord, N.H., U.S.A. This company also produces a headlap granule from hornfels, altered slate obtained from St. Bruno, Que.

Minnesota Minerals Limited, Havelock, Ont. crushes a basalt rock for naturally-coloured granules and also operates a colouring plant that produces a wide range of artificially-coloured granules. Crushing the rock produces size-ranges suitable for other applications as well.

Canada Crushed & Cut Stone Limited began producing in 1968 a naturally-coloured granule from a dolomitic limestone at St. Davids, Ont.

G.W. Richmond of Vancouver, B.C. produces granules from a slate and from a copper slag.

ROOFING PLANTS

Five companies manufactured roofing shingles at 14 locations in 1968. One company, The Philip Carey Company Ltd., Lennoxville, Que. went out of the roofing business when the plant was destroyed by fire in December, 1967. The plants operating in 1968 are as follows:

Building Products of Canada Limited
- Edmonton, Alta.
- Montreal, Que.
- Winnipeg, Man.

Canadian Gypsum Company, Limited
- Montreal, Que.
- Mont Denis, Ont.
- St. Boniface, Man.
- Vancouver, B.C.

Canadian Johns-Manville Company, Limited
- Asbestos, Que.

Domtar Construction Materials Ltd.
- Brantford, Ont.
- Burnaby, B.C.
- Lachine, Que.
- Lloydminster, Alta.

Iko Industries Limited
- Brampton, Ont.
- Calgary, Alta.

*Mineral Processing Division, Mines Branch.

TABLE 1

Consumption

	1967		1968	
	Short tons	$	Short tons	$
Consumption				
By kind				
Artificially coloured	80,953	2,626,672	93,444	2,915,293
Naturally coloured	64,784	1,242,731	76,241	1,414,385
Total	145,737	3,869,403	169,685	4,329,678
By colour				
Black and grey-black	64,088	1,327,721	99,715	1,757,371
White	21,338	741,723	23,136	931,579
Green	18,964	682,041	20,257	742,208
Brown and tan	7,514	233,080	9,655	311,092
Red	6,900	212,870	6,814	219,186
Grey	22,321	487,621	5,037	158,975
Blue	2,788	121,003	3,171	143,202
Coral	325	10,153	868	30,569
Buff	566	21,299	775	23,890
Turquoise	311	13,630	257	11,606
Not differentiated	622	18,262	–	–
Total	145,737	3,869,403	169,685	4,329,678
Canadian produced				
Artificially coloured	61,459	1,858,250	73,660	2,088,000
Naturally coloured	54,231	1,010,073	70,028	1,272,195
Total	115,690	2,868,323	143,688	3,360,195
Imported, United States				
Artificially coloured	19,494	786,422	19,784	827,293
Naturally coloured	10,553	232,658	6,233	142,190
Total	30,047	1,001,080	26,017	969,483

– Nil.

TABLE 2

Consumption 1958-68

			Percentage of Consumption Produced in Canada		
	Total Tons	Total Dollars	Naturally Coloured	Artificially Coloured	Total Granules
1968	169,685	4,329,678	91.9	78.8	84.7
1967	145,737	3,869,403	83.7	75.9	79.4
1966	133,857	3,573,939	82.6	77.7	79.7
1965	127,066	3,409,421	79.5	74.9	76.9
1964	140,890	3,852,704	72.4	75.0	73.9
1963	125,909	3,392,354	77.3	63.2	68.8
1962	125,463	3,476,875	57.6	60.8	59.0
1961	123,486	3,286,670	25.5	42.3	35.8
1960	113,826	2,962,363	31.4	50.8	44.7
1959	138,758	4,182,615	9.1	44.6	37.1
1958	134,565	4,229,980	11.3	34.6	30.4

TABLE 3

Average Granule Prices
($ per short ton)

	Canadian		Imported	
	1967	1968	1967	1968
Naturally coloured				
Rock	18.47	14.39	18.38	20.35
Slag	22.89	21.92	24.71	26.20
Slate	17.32	18.92	–	–
Artificially coloured				
Blue	41.24	43.10	49.02	50.46
Turquoise	36.57	40.00	49.26	50.78
White	30.88	38.44	41.32	43.86
Green	34.48	34.81	41.19	42.93
Coral	31.24	32.78	-	47.57
Brown and tan	29.64	30.81	36.57	38.45
Red	28.69	30.24	36.74	38.25
Grey	33.56	29.91	30.86	33.87
Buff	36.57	22.47	39.75	44.95
Black	23.62	14.20	36.97	35.26
Not differentiated	30.49	–	27.90	–
Average	29.88	28.35	36.06	41.82

– Nil.

Salt

W.E. KOEPKE*

Demand for salt and its chemical derivatives remained strong in 1968 and there are prospects for even greater requirements in 1969 and 1970. Markets for salt to control snow and ice on highways and city streets were particularly buoyant in Canada and the northern United States and production expanded accordingly. Demand for salt brines for the direct manufacture of heavy chemicals in Canada also remained strong and at the close of 1968 there was a sharp upward trend in production of caustic soda and chlorine to meet the needs of the pulp and paper and petrochemical industries. These two markets–snow and ice control and the manufacture of caustic soda and chlorine–together accounted for about two thirds of Canada's salt consumption in 1968.

The value of Canada's salt exports in 1968 remained relatively unchanged from the previous year. Salt imports reached an all time high of 644,000 tons in 1968, an increase of almost 14 per cent from 1967.

The operations and developments in Canada's salt industry in 1968 can be summarized as follows: three rock salt mines operated at capacity; seven evaporator plants operated at capacity; construction of a new salt processing and packaging plant at Belle Plaine, Saskatchewan, was started; plans to expand an evaporator plant at Unity, Saskatchewan, were announced; three new brine-based caustic soda plants were brought on stream–one each in Manitoba, Saskatchewan and Alberta; brine exports from Windsor, Ontario, to Detroit, Michigan, ceased; and rock salt was discovered in Newfoundland.

PRODUCTION AND DEVELOPMENTS IN CANADA

Preliminary statistics indicate that salt production in Canada in 1968 was 4.9 million tons valued at $32 million. Canadian salt production falls into three statistical classes: (1) mined rock salt, (2) fine vacuum salt, and (3) salt content of brines used or shipped and salt recovered in chemical operations. Production of mined rock salt, which accounted for 56 per cent of Canada's total salt output in 1967, increased by an estimated 230,000 tons in 1968. Output of fine vacuum salt in 1968 remained at nearly the same level as the previous four years. The decrease shown in the 1968 preliminary statistics is largely a result of the cessation at mid-year of brine exports from a field at Windsor, Ontario, to a soda ash plant in Detroit, Michigan. However, there were a number of changes in the brining segment of the salt industry in the closing months of 1968 that were not picked up in the preliminary statistical survey and it is anticipated the final figures for the year will reveal an increase in total salt production in 1968 rather than a decrease.

DEPOSITS AND OCCURRENCES

Salt occurs in solution in sea-water, in some spring and lake waters, in many subsurface waters, and in solid form in surface and underground deposits. Although sea-waters contain the largest reserve of salt and contribute substantial quantities of solar evaporated salt to the world's annual salt output, underground bedded and dome deposits supply the largest part of mankind's salt requirements.

In Canada, underground salt deposits have been found in all provinces except 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.

*Mineral Resources Branch.

TABLE 1

Canada, Salt Production and Trade, 1967-68

	1967		1968P	
	Short Tons	$	Short Tons	$
Production (shipments)				
By type				
Mine rock salt	3,023,397	14,759,281	..	..
Fine vacuum salt	554,337	10,180,917	..	..
Salt content of brines used or shipped and salt recovered in chemical operations	1,783,729	2,867,931	..	..
Total	5,361,463	27,808,129	4,887,634	31,907,986
By provinces				
Ontario	4,673,278	19,115,598	4,149,214	21,781,781
Nova Scotia	446,865	4,845,047	500,740	6,123,542
Alberta	126,135	1,827,422	127,892	1,976,000
Saskatchewan	89,732	1,452,131	80,000	1,304,000
Manitoba	25,453	567,931	29,788	722,663
Total	5,361,463	27,808,129	4,887,634	31,907,986
Imports				
Total, salt and brine				
United States	208,104	1,716,000	280,969	2,138,000
Mexico	234,382	345,000	215,777	366,000
Bahamas	79,520	328,000	101,840	415,000
Spain	43,244	173,000	33,647	136,000
Britain	14	1,000	9,450	39,000
Jamaica	1,748	8,000	1,344	6,000
Netherlands	–	–	1,125	17,000
Switzerland	–	–	1	2,000
Total	567,012	2,571,000	644,153	3,119,000
Exports				
United States	..	5,779,000	..	5,818,000
Jamaica	..	81,000	..	63,000
Bermuda	..	9,000	..	10,000
Leeward and Windward Islands	..	18,000	..	8,000
St. Pierre-Miquelon	..	1,000	..	6,000
New Zealand	..	13,000	..	5,000
Other countries	..	25,000	..	11,000
Total	..	5,926,000	..	5,921,000

Source: Dominion Bureau of Statistics.
PPreliminary; .. Not available; – Nil.

Ontario

Thick salt beds underlie much of southwestern Ontario extending from Amherstburg northeastward to London and Kincardine, bordering on what is known geologically as the Michigan Basin. As many as six salt beds, ranging in depths from 900 to 2,700 feet, can be identified and traced from drilling records; maximum bed thickness is 300 feet with aggregate thicknesses reaching as much as 700 feet. They occur in the Salina Formation of Upper Silurian age. The beds are relatively flat lying and undisturbed thereby permitting easy exploitation.

TABLE 2

Canada, Salt Production and Trade, 1959-68

	Production*	Imports	Exports
	(short tons)		$
1959	3,289,976	369,967	4,639,522
1960	3,314,920	191,940	3,461,366
1961	3,246,527	199,365	2,829,138
1962	3,638,778	245,836	3,987,668
1963	3,721,994	332,581	3,701,356
1964	3,988,598	405,574	3,618,569
1965	4,584,096	441,601	4,996,509
1966	4,492,034	509,548	3,588,000
1967	5,361,463	567,012	5,926,000
1968p	4,887,634	644,153	5,921,000

Source: Dominion Bureau of Statistics.
* Producers' shipments.
p Preliminary.

In 1968, these beds were being exploited through two rock salt mines–one at Goderich and the other at Ojibway–and through brining operations at four centres, Goderich, Sarnia, Windsor and Amherstburg. The Canadian Salt Company Limited reported that the brine export contract for its subsidiary, Canadian Brine Limited, at Windsor was terminated July 31, 1968. Canadian Brine had been supplying brines, via pipeline, for a soda ash plant in Detroit. The parent firm will continue to operate the brine field to supply its evaporator plant.

Early in 1969, Dome Petroleum Limited and Pan American Petroleum Corporation began a joint drilling project to develop a liquid petroleum gas storage cavern near Sarnia; the salt brines obtained are to be piped to Dow Chemical of Canada, Limited's nearby caustic soda-chlorine plant.

Maritime 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 as follows: 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.

Exploitation of these deposits in 1968 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 1967 and 1968, at least three companies conducted further exploration of salt deposits under mainland Nova Scotia and Cape Breton Island. Although no new salt or brine producing operations have been announced for the area, Canso Chemicals Limited, an associated company of Canadian Industries Limited and two pulp and paper companies, started constructing a chlor-alkali plant at Abercrombie Point, near New Glasgow, Nova Scotia; completion is expected in 1970.

In August 1968, it was announced that Hooker Chemicals Limited, had discovered salt beds near St. Fintans, southwestern Newfoundland. One hole intersected at least 425 feet of salt at a depth of about 1,000 feet. The Newfoundland deposit occurs within the same rock sequence as those in Nova Scotia and is believed to be of the tabular-dome type.

The rock salt deposits in Prince Edward Island occur at a depth of over 14,000 feet.

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 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 are relatively flat-lying and undisturbed. The same rock sequence contains a number of potash beds that are being exploited in Saskatchewan.

Three companies–one at Unity, Saskatchewan, and one each at Lindbergh and Two Hills, Alberta, have been producing salt and salt brines from these beds for a number of years. In the latter part of 1968, Dow Chemical of Canada, Limited brought a 300-ton-a-day caustic soda-chlorine plant on stream at Fort Saskatchewan, Alberta; an on-site brine field supplies the salt input. Also in 1968, Interprovincial Co-Operatives Limited expanded its caustic soda-chlorine plant at Saskatoon, Saskatchewan, and converted from purchased dry salt to an on-site brine field supply.

In mid-1968, The Canadian Salt Company Limited started construction of a $3-million salt processing and packaging plant one mile from Kalium Chemicals Limited's potash mine at Belle Plaine, Saskatchewan. The plant will have an annual productive capacity of 200,000 tons of fine evaporated salt from byproduct brines from Kalium's potash solution-mine. Production is scheduled to begin late in 1969. The Canadian

Salt Company has indicated that its Neepawa salt works in Manitoba will be closed when the Belle Plaine plant starts production. Domtar Chemicals Limited embarked on a $2.4-million expansion of its plant at Unity, Saskatchewan. Productive capacity is being increased from 92,000 tons to 150,000 tons annually in 1969 and provisions are being made for a further expansion to 200,000 tons annually should markets warrant it.

Elsewhere in the prairie provinces, Dryden Chemicals Limited brought a caustic soda-chlorine plant on stream late in 1968 at Brandon, Manitoba. Dryden's plant is fed by naturally-occurring brines pumped from a depth of 3,000 feet.

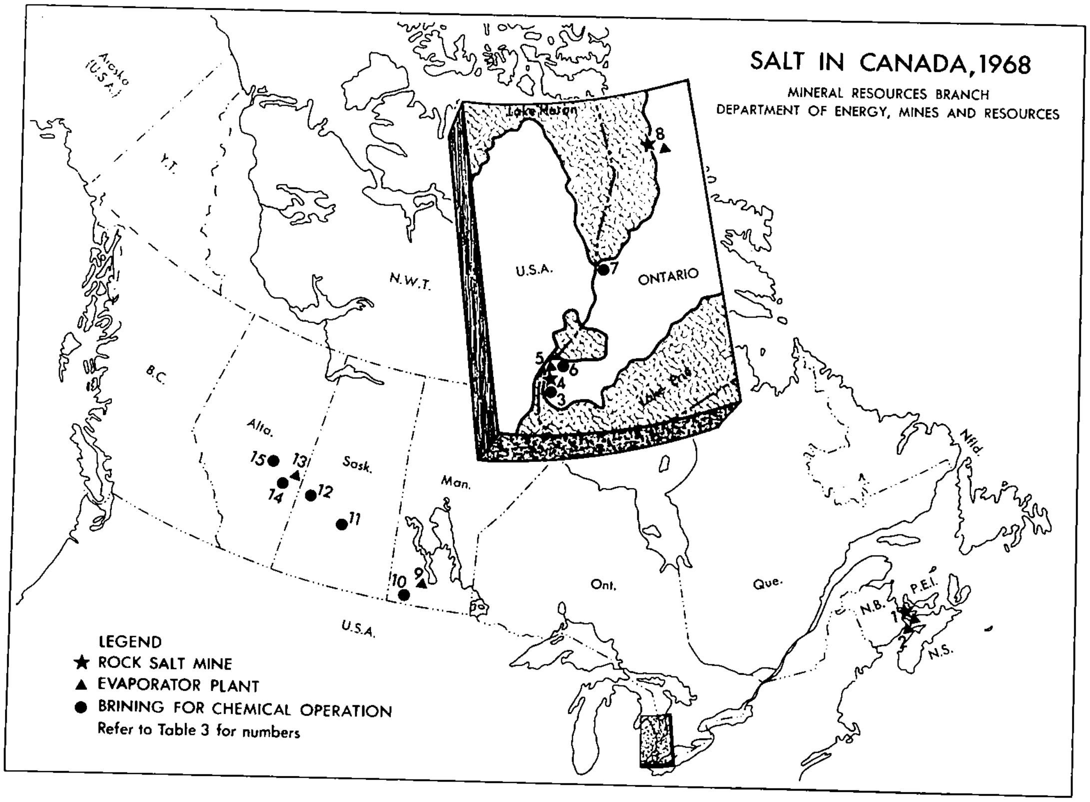
RECOVERY METHODS

Canadian producers employ two 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

TABLE 3

Canada, Summary of Salt and Brine Operations, 1968
(refer to map for numbers)

Company (refer to map for numbers)	Location	Initial Production	Remarks
1. The Canadian Rock Salt Company Limited	Pugwash, N.S.	1959	Rock salt mining at a depth of 630 feet.
	Pugwash, N.S.	1962	Dissolving rock salt fines for vacuum pan evaporation.
2. Domtar Chemicals Limited	Amherst, N.S.	1947	Brining for vacuum pan evaporation.
3. Allied Chemical Canada, Ltd.	Amherstburg, Ont.	1919	Brining to produce soda ash.
4. The Canadian Rock Salt Company Limited	Ojibway, Ont.	1955	Rock salt mining at a depth of 980 feet.
5. The Canadian Salt Company Limited	Windsor, Ont.	1892	Brining, vacuum pan evaporation and fusion.
6. Canadian Brine Limited	Windsor, Ont.	1958	Brining to supply soda ash plant in Detroit; ceased operation July 1968.
7. Dow Chemical of Canada, Limited	Sarnia, Ont.	1950	Brining to produce caustic soda and chlorine.
8. Domtar Chemicals Limited	Goderich, Ont.	1959	Rock salt mining at a depth of 1,760 feet.
	Goderich, Ont.	1880	Brining for vacuum pan evaporation.
9. The Canadian Salt Company Limited	Neepawa, Man.	1932	Pumping natural brines for vacuum pan evaporation.
10. Dryden Chemicals Limited	Brandon, Man.	1968	Pumping natural brines to produce caustic soda and chlorine.
11. Interprovincial Co-Operatives Limited	Saskatoon, Sask.	1968	Brining to produce caustic soda and chlorine.
12. Domtar Chemicals Limited	Unity, Sask.	1949	Brining, vacuum pan evaporation and fusion.
13. The Canadian Salt Company Limited	Lindbergh, Alta.	1948	Brining, vacuum pan evaporation and fusion.
14. Chemcell Limited	Two Hills, Alta.	1953	Brining to produce caustic soda and chlorine.
15. Dow Chemical of Canada, Limited	Ft. Saskatchewan, Alta.	1968	Brining to produce caustic soda and chlorine.



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 salt or can be used directly in the manufacture of sodium-bearing chemicals. Recovery of salt from natural subsurface brines is accomplished in a similar manner. A third method of producing salt 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 feet 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 undergound. The products, ranging in size from about one half inch to a fine powder, normally have a purity of 96 per cent or better. Most of the gypsum, anhydrite, and limestone impurities are removed by crushing and screening; removal of remaining amounts of these impurities from small proportions of the coarser salt fractions is achieved with the use of electronic sorters.

Most of the mined rock salt in Canada is shipped in bulk via 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 pumping a saturated salt solution to the surface. Water injection and brine recovery can be accomplished in a single bore hole 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 dry salt or used directly in the manufacture of chemicals.

TABLE 4

World Salt Production
('000 short tons)

	1967p
United States	38,946
China (mainland)	14,300
USSR	10,500
Britain	. .
West Germany	. .
India	6,200
France	4,961
Canada	5,361
Italy	4,500
Other countries	26,546
Total	111,314

Source: U.S. Bureau of Mines, Minerals Yearbook, 1967.
p Preliminary; . . Not available.

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 or 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 suited for use in water softeners.

CANADIAN CONSUMPTION AND TRADE

Salt is marketed in at least 100 different forms, packages and containers and its direct and indirect uses number in the thousands. The largest single market for salt in Canada in 1968 was for snow and ice control on highways and city streets. By comparison to other uses, this market is new, having expanded in Canada from less than 100,000 tons in 1954 to an estimated 1.6 million tons in 1968.

TABLE 5

Canada, Available Data on Salt Consumption, 1966-68
(short tons)

	1966	1967e	1968e
Industrial chemicals	1,322,284	1,390,000	1,450,000
Snow and ice control	1,200,000e	1,400,000	1,600,000*
Slaughtering and meat packing	50,312	57,000	65,000
Food processing	65,777	68,000	70,000
Starch, glucose, malt	13,912	14,000	14,500
Breweries	626	650	650
Pulp and paper	64,427	66,000	68,000
Leather tanneries	5,747	6,000	6,000
Soaps and cleaning compounds	2,870	3,000	3,000
Dyeing and finishing textiles	1,542	1,600	1,600
Artificial ice	267	300	300
Fishing industry	75,000e	75,000	75,000
Farm stock	46,000e	48,000	50,000

Source: Dominion Bureau of Statistics.
* Salt Institute; e Estimated.

Prior to 1967, Canada's largest consumer of salt was the industrial chemical industry, which used it mainly for the manufacture of caustic soda (sodium hydroxide) and chlorine. About 1.6 tons of salt is required to produce one ton of caustic soda, grading 76 per cent Na_2O, and a proportionate amount of chlorine. At the end of 1968, there were 22 caustic soda-chlorine plants operating in Canada, four of which were either built or expanded during the year. Combined annual productive capacity of the 22 plants is an estimated 1 million tons of caustic soda and 860,000 tons of chlorine. As indicated in Table 3, salt for five caustic soda-chlorine plants is obtained from on-site brining. With the exception of three plants in the west coast area, most of the remaining caustic soda-chlorine manufacturers acquire their salt from domestic suppliers. Production of these two chemicals in Canada in 1968 was 844,266 tons of caustic soda and 741,281 tons of chlorine compared with 805,891 tons and 700,338 tons, respectively, in 1967. The pulp and paper and petrochemical industries are large consumers of caustic soda and chlorine. 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 bulk of Canada's salt exports go to United States, mostly in the form of mined rock salt and brine.

Most of Canada's salt imports serve west coast markets and consist of solar salt from the San Francisco Bay area of United States, Mexico and Bahamas. Solar salt contains 3 to 4 per cent moisture but this presents no problem when being used in chemical manufacture or the fishing industry. Small quantities of the solar salt are dried and processed at Port Mann, near Vancouver, British Columbia, for sale in west coast markets; the operation, formerly known as Vancouver Salt Company, Ltd., was purchased by Domtar in 1967. Salt imports from Spain are largely for the fishing industry on the east coast.

OUTLOOK

The outlook for Canada's salt industry is favourable. Demand for salt for snow and ice control on city streets and on highways has increased sharply in the past few years and the trend is expected to continue. Likewise, demand for salt-based chemicals has been strong and is expected to be even stronger in 1969 and 1970. Production and shipments of salt in 1969 may not reflect the strong demand because of labor disputes and strikes at Canadian Salt Company's Ojibway mine and Windsor evaporation plant in the early part of the year. In spite of the loss of large export markets for salt brines in 1968, output is expected to increase steadily during the next few years.

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. Some of the reductions made by Canada and United States are as follows:

	Jan. 1, 1968 to Dec. 31, 1968	Jan. 1, 1969
CANADA		
(Most Favoured Nation Rates)		
Fishery salt	free	free
Common salt (including rock salt, sea salt, pure sodium chloride)	3½¢ per 100 lb	2¢ per 100 lb
Table salt made by an admixture of other ingredients, when containing not less than 90% of pure salt	9% ad valorem	8% ad valorem
Salt liquors and sea-water	free	free

UNITED STATES		
Bulk salt	1.5¢ per 100 lb	1.3¢ per 100 lb
Salt in bags	2.5¢ per 100 lb	2¢ per 100 lb
Salt in brine	9% ad valorem	8% ad valorem

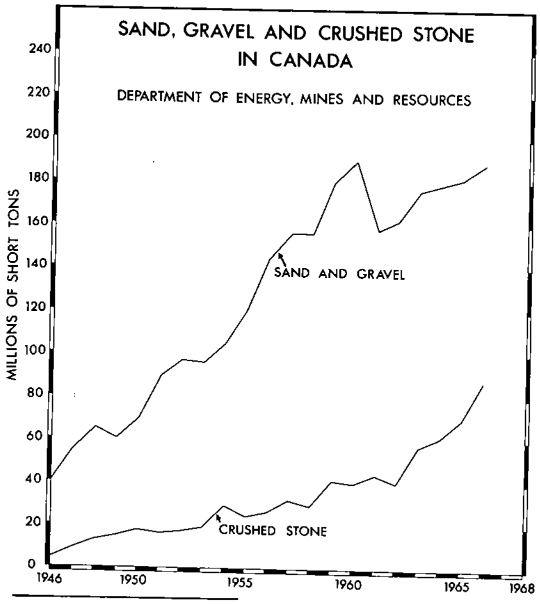
Sources: The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa. Tariff Schedules of the United States, Annotated 1969, TC Publication 272.

Sand, Gravel and Crushed Stone

F.E. HANES*

The estimated production of sand and gravel and crushed stone in 1968 amounted to 292,000,000 short tons and $240,000,000.

These estimated figures are calculated from the previous years values on the basis that some slowing down in production from the peak years in 1966-67 is prevalent in some phases of the construction industry. In some cases overproduction, in others rising costs and stoppages are all responsible for the slow-down. From the 1967 review, which is obtainable as a separate copy only, half the per cent increase used to calculate the production from 1966 to 1967 will be used to provide the 1968 values. Thus the 1967 volume of 285.9 million short tons will be multiplied by half the per cent increase used in the previous years calculations, or 1.021 per cent of the 1967 volume and 1.024 per cent to obtain the 1968 value from the 1967 value of $234,300,000.



*Mineral Processing Division, Mines Branch.

No new statistics were available for the 1968 review so the 1967 review will be used to provide all available information in the Mineral Statistics annual publication.

Values of production obtained for the past two reviews were calculated on the previous years productivity. The increases from 1965 to 1966 for example, amounted to approximately 22 per cent volume and 15 per cent value for crushed stone, 2.7 per cent volume and 13.1 per cent value for total sand and gravel (includes crushed gravel), and increases for Total Sand and Gravel and Crushed Stone were 8.3 per cent for volume and 9.6 per cent for value.

Table 1 shows the 1965 and 1966 production of sand and gravel by provinces (including crushed gravel), crushed stone and a combination of these two – Total Sand and Gravel and Crushed Stone. Table 2 gives the sand and gravel, crushed gravel and crushed stone production by types of use.

Anticipating a slowing down in the rate of increase of production but still looking for increased production in 1967 compared with 1966, estimates are made by applying one half the per cent of increase of 1966 production over 1965 or 4.2 per cent increase in volume and 4.8 per cent increase in value, i.e., 1.042 of the 1966 volume and 1.048 of the 1966 value of Total Sand and Gravel and Crushed Stone product.

A vast quantity of material in the natural aggregate and crushed stone industries was required during the years 1966 and 1967 for construction of Expo 67. Reference to Tables 1 and 2 show the increase in production volume and value continuing into 1966 from 1965 which, in turn, showed the same type of increases over 1964.

Total sand and gravel reported by the Dominion Bureau of Statistics, not to be confused with the sand and gravel herein reported, shows a continuing increase into 1967 of 4.7 million short tons over the 1966 production of 217,238,710 short tons for an increased value of $6.6 million over the 1966 value of $151,525,102.

TABLE 1

Sand, Gravel and Crushed Stone 1965-1966

	1965		1966	
	Short Tons	$	Short Tons	$
PRODUCTION				
By provinces				
Sand and Gravel				
Newfoundland	4,063,734	3,684,891	3,327,216	3,406,721
Prince Edward Island	412,064	374,081	660,726	1,162,513
Nova Scotia	6,574,387	4,498,803	8,084,412	10,743,785
New Brunswick	4,491,514	2,594,846	719,442	726,968
Quebec	40,507,369	19,583,351	41,110,007	20,172,395
Ontario	75,082,026	55,297,474	83,039,157	61,730,806
Manitoba	9,757,104	6,767,068	8,952,396	5,382,531
Saskatchewan	8,570,008	5,615,794	7,998,574	4,836,205
Alberta	13,163,941	10,661,383	11,885,541	9,719,584
British Columbia	20,484,706	12,662,016	22,285,372	20,503,576
Total	183,106,853	121,739,707	188,062,843	138,385,084
Crushed Stone				
Newfoundland	163,000	406,703	131,893	233,572
Prince Edward Island	225,306	225,306	200,000	200,000
Nova Scotia	165,730	345,921	543,101	1,524,974
New Brunswick	2,001,670	2,331,606	3,194,379	2,010,821
Quebec	42,119,022	41,052,148	54,245,806	47,137,505
Ontario	22,198,449	26,364,747	23,466,872	28,166,429
Manitoba	598,552	556,133	1,948,547	2,087,931
Saskatchewan	–	–	–	–
Alberta	1,008	1,425	–	–
British Columbia	3,032,052	3,165,706	2,641,252	3,809,464
Total	70,504,789	74,449,695	86,371,850	85,170,696
Total Sand and Gravel and Crushed Stone				
Newfoundland	4,226,734	4,091,594	3,459,109	3,640,293
Prince Edward Island	637,370	599,387	860,726	1,362,513
Nova Scotia	6,740,117	4,844,724	8,627,513	12,268,759
New Brunswick	6,493,184	4,926,452	3,913,821	2,737,789
Quebec	82,626,391	60,635,499	95,355,813	67,309,900
Ontario	97,280,475	81,662,221	106,506,029	89,897,235
Manitoba	10,355,656	7,323,201	10,900,943	7,470,462
Saskatchewan	8,570,008	5,615,794	7,998,574	4,836,205
Alberta	13,164,949	10,662,808	11,885,541	9,719,584
British Columbia	23,516,758	15,827,722	24,926,624	24,313,040
Total	253,611,642	196,189,402	274,434,693	223,555,780

–Nil.

Crushed stone which is buried in the statistics (reported by the D.B.S.) for total stone 1967 is not predictable. It is likely that crushed stone will continue to increase, however, when reference is made to the construction values (reported by the D.B.S.) which shows a decided increase for residential construction from 2,843 in 1966 to 3,065 in 1967 with the preliminary forecasts for 1968(p) indicating a continuation of this trend. Total building for the same years increased from 6,661 through 6,826 to 7,283(p) by 1968. It is therefore highly probable that increased production of materials used in building will show increases through 1967 to 1968.

The volume and value of sand and gravel production in 1967 and 1968 is reported by the Dominion Bureau of Statistics and is shown in Table 3. A small amount of sand production included in Table 3 does not appear in the values shown in Tables 1 and 2. Such items as engine sand, mine fill, etc. are omitted in our tables. Information in Table 3 does

TABLE 2

Sand, Gravel and Crushed Stone 1965-1966

	1965		1966	
	Short Tons	$	Short Tons	$
PRODUCTION				
By Type				
Sand and Gravel				
For roads (roadbed surface)	93,370,062	49,954,863	96,416,278	63,584,170
Concrete aggregate	27,028,097	24,085,180	26,152,005	25,144,138
Asphalt aggregate	4,766,590	4,482,596	3,809,321	3,459,475
Railroad ballast	4,162,023	1,700,212	2,545,155	887,246
Mortar sand	2,362,725	1,966,241	2,190,420	2,120,513
Total	131,689,497	82,189,092	131,113,179	95,195,542
Crushed Gravel				
For roads (roadbed surface)	36,724,584	24,329,274	42,656,612	28,979,956
Concrete aggregate	6,592,767	8,887,195	6,106,694	7,241,244
Asphalt aggregate	2,902,775	2,544,793	2,390,426	2,956,834
Railroad ballast	2,224,443	1,685,542	1,292,134	1,134,421
Other uses	2,972,787	2,103,811	4,503,798	2,877,087
Total	51,417,356	39,550,615	56,949,664	43,189,542
Total Sand, Gravel and Crushed Gravel	183,106,853	121,739,707	188,062,843	138,385,084
Crushed Stone				
Concrete aggregate	14,803,700	17,559,720	18,138,461	19,605,453
Railway ballast	2,809,888	3,266,572	2,548,798	3,020,274
Road metal	44,833,827	44,914,770	47,687,783	47,201,327
Rubble and riprap	2,072,279	2,255,005	12,125,808	8,866,998
Terazzo, stucco and artificial stone	154,507	1,071,993	126,116	1,131,950
Other uses	5,330,588	5,381,635	5,744,884	5,344,694
Total	70,504,789	74,449,695	86,371,850	85,170,696
Total Sand, Gravel, Crushed Gravel and Crushed Stone	253,611,642	196,189,402	274,434,693	223,555,780

indicate that production appears to remain strong through 1967 but drops off in 1968. The latter value, however, is preliminary.

Ontario, Quebec, British Columbia and Nova Scotia were the principal provinces showing marked increases in production of natural aggregates such as sand and gravel and crushed gravel. The four provinces, in the order named, produced 44, 22, 12 and 4.3 per cent of the natural aggregate in 1966, amounting to over 82 per cent of the total produced in Canada. These four provinces shared in the value approximately 44, 14.6, 14.9 and 7.8 respectively for an 81.3 per cent share of the total production. Of all the other provinces, New Brunswick reported a tremendous drop in production from 4.5 million to 719,442 short tons and a decrease in value from $2.6 million in 1965 to $726,968.

Quebec led in the production of crushed stone with 63 per cent of the total 86.4 million short tons for a 55.5 share of the total value of $85.2 million. Ontario, the other principal user of crushed stone produced 27 per cent and 33 per cent of the total product. These two provinces produced 90 per cent of the Canadian volume of crushed stone and share 88.5 per cent of the total value.

Ontario with 39 per cent closely followed by Quebec with 35 per cent and British Columbia 9.1 per cent were the three principal producers of the total sand, gravel and crushed stone product. Alberta, Manitoba and Nova Scotia with 4.3, 4 and 3.5 per cent of the production followed the first three. Ontario with 40 per cent and Quebec with 30 per cent captured a large share of the total value for this production. Two others who shared 11 and 5.5 per cent of the value were British Columbia and Nova Scotia.

The largest consumer of aggregates is road building claiming 73 per cent of natural sand and gravel and 55 per cent of the crushed stone product. More than 75 per cent of crushed gravel goes into road construction.

TABLE 3

Canada – Sand and Gravel Production and Trade
1967 and 1968

	1967		1968p	
	Short Tons	$	Short Tons	$
Production, by provinces				
Newfoundland	3,143,938	3,086,688	2,633,889	2,260,819
Prince Edward Island	5,155,257	1,986,657	499,724	887,187
Nova Scotia	6,056,265	3,912,213	5,154,461	2,719,699
New Brunswick	7,604,962	4,382,988	5,168,697	2,973,105
Quebec	35,637,867	17,931,394	35,317,769	18,531,010
Ontario	94,751,250	67,664,191	93,645,523	57,777,676
Manitoba	10,289,157	6,381,206	10,229,546	6,815,263
Saskatchewan	9,671,401	5,526,002	9,287,792	5,455,462
Alberta	14,187,340	11,928,771	13,052,578	11,687,734
British Columbia	23,168,141	20,906,733	23,538,608	18,992,836
Total Canada	209,665,578	143,706,843	198,528,587	128,100,791

pPreliminary.

Approximately 20 per cent of sand and gravel and 21 per cent of crushed stone production goes into concrete, the second largest consumer of aggregate materials.

All aggregate materials for roads and concrete are valued at approximately $1.00 per ton excepting sand and gravel which has a value of about 66 cents a ton.

Natural deposits of sand and gravel continue to be depleted. Similar volumes were produced in 1966 as well as in 1965. Some increase in crushed gravel resulted but did not change in value per ton to produce. Crushed stone dropped from $1.06 per ton, 1965, to 98.6 cents per ton in 1966.

IMPORTS AND EXPORTS

Table 4 shows the Exports and Imports of aggregate materials without classification. Neither is significant in the industry in Canada.

TABLE 4

Imports and Exports – Sand, Gravel and Crushed Stone

	1967		1968p	
	Short Tons	$	Short Tons	$
Exports				
United States	601,222	855,000	496,230	535,000
West Germany	64	4,000	220	1,000
Other countries	133	2,000	75	2,000
Total	601,419	861,000	496,525	538,000
Imports				
United States	757,403	824,000	683,490	642,000
Britain	200	1,000	–	–
Total	757,603	825,000	683,490	642,000

pPreliminary; –Nil;

Selenium and Tellurium

A. F. KILLIN*

SELENIUM

Selenium occurs sparsely disseminated throughout the earth's crust in a wide variety of selenium-bearing minerals. None of these minerals occurs in sufficient concentration to allow commercial exploitation for their selenium content alone and production is derived as a byproduct of copper and lead smelting.

Non-communist world production is distributed among the copper-refining nations including Canada, United States, Japan, Australia, Belgium and Luxembourg, Finland, Mexico, Zambia, Peru and Sweden. There is also production in the USSR and other communist nations. Selenium supply is dependent upon copper production and because of this, it fluctuates with the rate of copper output and not in response to demand.

Canada's selenium production in 1968 was 709,000 pounds valued at $3,280,345, a decrease of 15,373 pounds and $233,834 from 1967. Domestic consumption averages about 20,000 pounds annually; the balance is exported or stockpiled. Britain and United States are the major export markets for Canadian selenium, absorbing nearly 93 per cent of the total exported. No sudden change is expected in the pattern of consumption and exports.

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 Gaspé 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% Se), high-purity metal (99.9% Se) and a great variety of metallic and organic selenium compounds. Annual capacity is 450,000 pounds of selenium in metals and salts.

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 a minus 200-mesh selenium powder (99.5%).

*Mineral Resources Branch.

TABLE 1

Canada – Selenium – Production, Exports and Consumption, 1967-68

	1967		1968P	
	Pounds	$	Pounds	$
Production				
All forms[1]				
Quebec	521,174	2,527,694	455,000	2,047,500
Ontario	134,800	653,780	126,500	613,500
Manitoba	31,274	151,679	72,484	351,547
Saskatchewan	37,325	181,026	55,216	267,798
Total	724,573	3,514,179	709,200	3,280,345
Refined[2]	754,360		620,033	
Exports (metal)				
United States	266,500	1,405,000	508,400	3,009,000
Britain	229,600	1,431,000	225,000	1,215,000
Philippines	3,600	16,000	12,000	51,000
New Zealand	200	1,000	11,500	54,000
Argentina	10,100	48,000	7,100	32,000
Republic of South Africa	4,300	20,000	6,100	28,000
Spain	5,800	30,000	5,500	28,000
Other countries	19,300	89,000	11,500	48,000
Total	539,400	3,040,000	787,100	4,465,000
Consumption[3] (selenium content)	21,017		21,440	

Source: Dominion Bureau of Statistics.
[1]Recoverable selenium content of blister copper treated at domestic refineries, plus refined selenium from domestic primary materials. [2]Refinery output from all sources. [3]Consumption of selenium products (metal, metal powder, oxide), selenium content, as reported by consumers.
PPreliminary.

CONSUMPTION AND USES

Selenium is used in the glass, rubber, chemical, steel and electronics industries. Development of the dry-plate rectifier during World War II brought about a sharp increase in the demand for selenium that persisted into the post-war 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 prices and the efforts of the Selenium and Tellurium Development Association have gradually built up new markets and recaptured some of the lost markets. Sales and consumption have increased and steady growth in demand is forecast.

Canadian consumption of selenium in 1968 was 21,440 pounds of which approximately half was in the manufacture of glass; the rest was in the rubber, electronics, steel and pharmaceutical industries.

Selenium is used in glassmaking both as a decolourizer 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. The ceramics and paint industries use selenium as a pigment to obtain colours from orange to dark maroon and in the colouring of inks for printing on glass containers.

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.

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 ageing and mechanical properties of sulphurless and low-sulphur rubber stocks. Selenac acts as an accelerator in butyl rubber.

TABLE 2

Canada – Selenium – Production, Exports and Consumption, 1959-68
(pounds)

	Production		Exports Metals and Salts[3]	Consumption[4]
	All Forms[1]	Refined[2]		
1959	368,107	372,410	325,712	22,156
1960	521,638	524,659	404,410	14,461
1961	430,612	422,955	345,800	13,160
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[p]	709,200	620,033	787,100	21,440

Source: Dominion Bureau of Statistics.
[1]Recoverable selenium content of blister copper treated at domestic refineries, plus refined selenium from domestic primary material. [2]Refinery output from all sources. [3]From 1959 to 1960, exports of selenium metal and compounds; from 1961, exports of metal, metal powder, shot, etc. [4]Consumption (selenium content), as reported by consumers.
[p]Preliminary.

TABLE 3

Non-Communist World Production of Selenium, 1966-68
(pounds)

	1966	1967	1968[e]
United States	620,000	598,000	. .
Canada	575,482	724,573	709,200
Japan	421,190	422,172	450,000
Sweden	181,000[re]	170,000[e]	170,000
Belgium and Luxembourg	91,271[r]	90,400	100,000
Zambia	58,000[e]	. .	. .
Other countries	53,834	35,900	100,000
Total	2,000,777	2,041,045	. .

Source: U.S. Bureau of Mines Minerals Yearbook, 1967, and U.S. Bureau of Mines Commodity Data Summaries, January, 1969.
[e] Estimated; . . Not available; [r]Revised.

TABLE 4

Canada – Industrial Use of Selenium, 1966-68
(pounds of contained selenium)

	1966	1967	1968
By end-use			
Glass	6,512	10,226	10,787
Other*	14,021	10,791	10,653
Total	20,533	21,017	21,440

Source: Consumers' reports to Dominion Bureau of Statistics.
* Electronics, rubber, steel, pharmaceuticals.

Selenium, in proportions from 0.20 to 0.35%, improves the porosity of stainless steel castings. Ferroselenium (55 to 57% Se) is added to stainless and lead-recarburized steels to improve their machineability and other properties.

PRICES

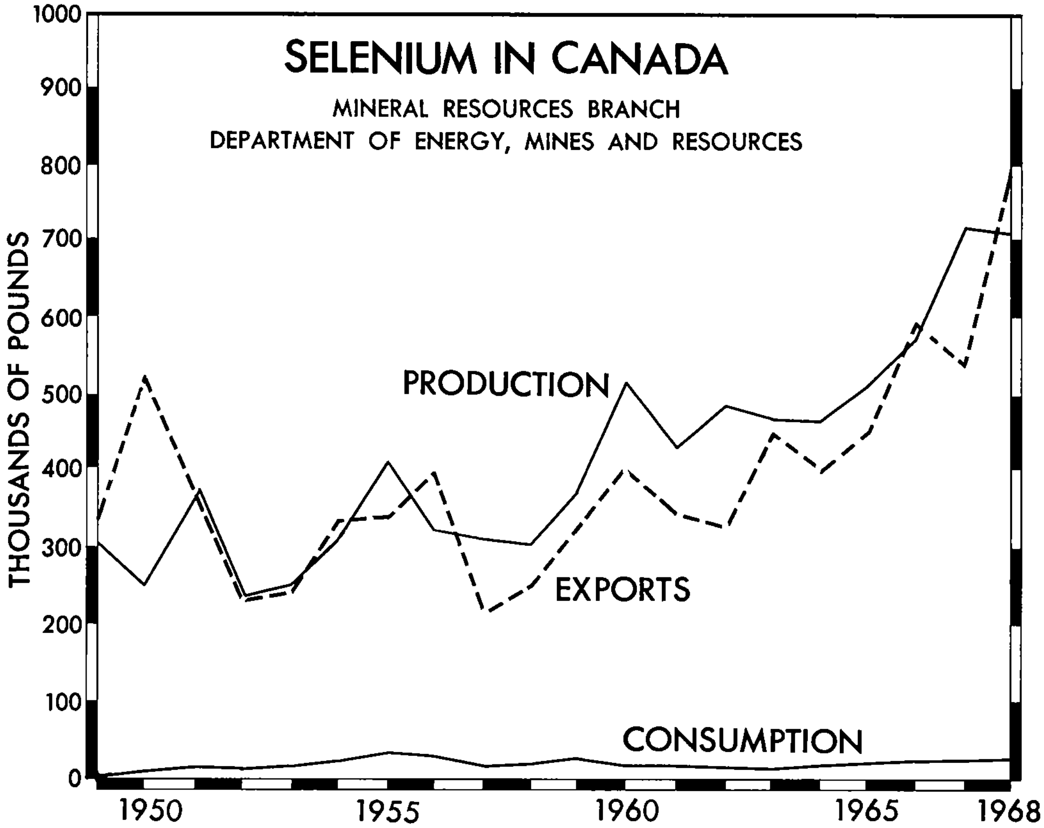
Throughout 1968 selenium prices, per pound of selenium, in the United States, were quoted by *Metals Week* as follows:

Commercial grade powder	– $4.50
High-purity selenium	– $6.00

TARIFFS

	Most Favoured Nation*
CANADA	
Selenium metal	10%
UNITED STATES	
Selenium metal, unwrought and selenium waste and scrap	free
Selenium metal alloys, unwrought	14%
Selenium dioxide and salts	free

Sources: The Custom Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa.
Tariff Schedules of the United States Annotated (1969) TC Publication 272.
* Effective on and after January 1, 1969.



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. Production in 1968 was 65,193 pounds valued at $419,990 compared with the 73,219 pounds valued at $475,925 produced in 1967. Refined production in 1968 was 65,926 pounds.

CONSUMPTION AND USES

Tellurium is recovered from the same sources as selenium and therefore its production and growth of consumption are governed by the same factors. Low production and the 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.

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 ageing 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 for butyl rubber.

TABLE 5

Canada – Tellurium – Production and Consumption, 1967-68

	1967		1968p	
	Pounds	$	Pounds	$
Production				
All forms[1]				
Quebec	56,685	368,453	47,000	305,500
Ontario	6,500	42,250	6,600	39,600
Manitoba	4,575	29,738	6,581	42,513
Saskatchewan	5,459	35,484	5,012	32,377
Total	73,219	475,925	65,193	419,990
Refined[2]	70,105		65,926	
Consumption[3] (refined)	1,005		2,405	

Source: Dominion Bureau of Statistics.
[1]Includes the recoverable tellurium content of blister copper treated plus refined tellurium from domestic primary material. [2]Refinery output from all sources. [3]Producers' domestic shipment.
p Preliminary.

TABLE 6

Canada – Production and Consumption of Tellurium
1959 to 1968
(pounds)

	Production		Consumption
	All Forms[1]	Refined[2]	Refined[3]
1959	13,023	8,900	9,677
1960	44,682	41,756	4,238
1961	77,609	81,050	4,843
1962	58,725	57,630	4,306
1963	76,842	79,640	1,853
1964	77,782	80,255	1,473
1965	69,794	69,930	1,870
1966	72,239	72,745	862
1967	73,219	70,105	981
1968p	65,193	65,926	2,405[4]

Source: Dominion Bureau of Statistics.
[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. [3]Consumption as reported by consumers. [4]Producers' domestic shipments.
pPreliminary.

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, 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.

TABLE 7

Non-Communist World Production of Tellurium
(pounds)

	1966	1967	1968e
United States	199,000	135,000	140,000
Canada	72,239	73,219	65,193
Peru	39,654	–	40,000
Japan	22,701	29,760	30,000
Other countries	–	–	–
Total	333,594	237,979	..

Source: U.S. Bureau of Mines Minerals Yearbook, 1967 and U.S. Bureau of Mines Commodity Data Summaries, January, 1969.
e Estimated; .. Not available.

TABLE 8

Refined Tellurium Used in Canada, 1966-68
(pounds of contained tellurium)

	1966	1967	1968
By end-use			
Metal alloys	862	981	. .
Total	862	981	. .

Source: Consumers' reports to Dominion Bureau of Statistics.

. . Not available for publication on a comparable basis.

PRICES

Throughout 1968 the prices of tellurium in the United States per pound of tellurium as quoted by *Metals Week* were as follows:

Powder, 100 pound lots – $6.00
Slab, 150 pound lots – $6.00

TARIFFS

	Most Favoured Nation*
CANADA	
Tellurium metal	10%
UNITED STATES	
Tellurium metal	6%
Unwrought, waste and scrap	
Tellurium compounds and salts	8%

Sources: The Custom Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa.

Tariff Schedules of the United States Annotated (1969) TC Publication 272.

* Effective on and after January 1, 1969.

Silica

P.R. COTE*

Silica (SiO_2) occurs in the earth's crust as the mineral quartz in unconsolidated sands, sandstones, quartzite and as vein quartz. The mineral is very abundant but seldom does it occur in sufficient tonnage and purity to be extracted profitably. Further, because of its low unit value an economically viable deposit should be mineable by low-cost open-pit methods and be located close to consuming areas in order to minimize transportation costs. Principal consuming industries and uses for silica include: glass manufacture; metallurgical works where silica is utilized as a flux; abrasive manufacture where silica is used to produce ferrosilicon and silicon carbide; sand blasting; manufacture of silicon; foundry sands for metal castings; and filler materials in tile, asbestos pipe, cement blocks and bricks.

Production of silica in Canada in 1968 increased moderately from 1967 to reach 2.6 million tons valued at $6.5 million; its value increased 17 per cent. As in previous years, most of the output was low-grade lump silica and low-grade sand for use primarily as a metallurgical flux. Canada imports substantial quantities of high-grade silica sand almost all from the United States, for use in glass manufacture. In 1968, imports of silica sand amounted to 1,107,000 tons valued at $4,263,000 a tonnage increase of 16 per cent from 1967 and a value increase of 2 per cent. Silica sand suitable for glass manufacture is produced by two companies in Canada. Indusmin Limited, the largest, operates two quarries in Quebec. The Winnipeg Supply and Fuel Company, Limited operates a silica sand deposit on Black Island in Lake Winnipeg.

*Mineral Resources Branch.

PRINCIPAL PRODUCERS AND DEVELOPMENTS

NEWFOUNDLAND

Newland Enterprises Limited, a subsidiary of Armand Sicotte et Fils Limitee, began producing silica in 1968 from a newly-developed 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 newly-built $40-million phosphorus plant, requires about 200,000 tons of silica annually.

QUEBEC

Indusmin Limited, formerly Industrial Minerals of Canada Limited, produces a wide variety of silica products 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 located near St. Donat. Material from the St. Donat quarry is trucked some 50 miles for processing at the St. Canut mill. Products produced at St. Canut include: silica sand suitable for glass and silicon carbide manufacture, and as a foundry sand; finely ground silica flour for use as a filler material in tile, asbestos pipe, and in cement blocks, and bricks. The silica sand is sold in Quebec, the balance of the Quebec market being supplied by a producer in the United States.

TABLE 1

Canada–Silica-Production and Trade 1967-68

	1967		1968p	
	Short Tons	$	Short Tons	$
Production, quartz and silica sand[1]				
By province				
Ontario	1,193,122	463,050	1,230,643	1,000,900
Quebec	689,477	3,255,614	847,217	4,176,126
Manitoba	474,660	1,120,355	413,498	810,198
Saskatchewan	172,913	178,446	74,993	59,994
British Columbia	68,579	408,952	43,175	311,125
Nova Scotia	9,455	51,942	9,300	51,000
Alberta	2,534	51,685	2,500	50,000
Total	2,610,740	5,530,044	2,621,326	6,459,343
By use				
Flux	1,818,810	1,510,794		
Ferrosilicon	170,785	846,383		
Silicon carbide	58,549	348,252		
Glass	135,843	794,372		
Other uses[2]	426,753	2,030,243		
Total	2,610,740	5,530,044	2,621,326	6,459,343
Imports				
Silica sand				
United States	948,195	3,839,000	1,104,312	4,233,000
Sweden	–	–	2,688	30,000
Norway	2,204	43,000	–	–
Australia	1,926	126,000	–	–
Britain	134	...	–	–
Total	952,459	4,008,000	1,107,000	4,263,000
Silex and crystallized quartz				
United States	126	140,000	112	115,000
Brazil	5	242,000	4	103,000
Other countries	11	3,000	–	–
Total	142	385,000	116	218,000
	(Thousands)	$	(Thousands)	$
Firebrick and similar shapes, silica				
United States	1,889	1,587,000	1,150	973,000
West Germany	52	19,000	2	3,000
Belgium and Luxembourg	–	–	1	1,000
Total	1,941	1,606,000	1,153	977,000
	Short Tons	$	Short Tons	$
Exports				
Quartzite				
United States	56,200	170,000	64,086	181,000

Source: Dominion Bureau of Statistics.

[1]Producers' shipments, including crude and crushed quartz, crushed sandstone and quartzite, and natural silica sand. [2]Includes foundry uses, sand blasting, silica brick, concrete products, chemical manufacture and building products.

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

TABLE 2

Canada–Silica-Production and Trade, 1959-68
(short tons)

	Production		Imports			Exports	Consumption
	Quartz and silica sand	Silica brick[1] (000's brick)	Silica sand	Silex or crystallized quartz	Flint and ground flintstones	Quartzite	Quartz and silica sand
1959	2,163,546	1,926	792,129	13,815	786	147,412	2,535,059
1960	2,260,766	..	720,826	10,521	1,232	13,057	2,709,669
1961	2,194,054	..	693,210	10,327	1,339	26,774	2,648,265
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
1968p	2,621,326	..	1,107,000	116	..	64,086	..

Source: Dominion Bureau of Statistics.
[1]Not available after 1959. Beginning 1960; silica to make silica brick included in production of quartz and silica sand.
pPreliminary; .. 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 also quarries sandstone in the Melocheville area for use by Chromium Mining & Smelting Corporation, Limited, in the manufacture of ferrosilicon also at Beauharnois.

Baskatong Quartz Products produces lump silica and crushed quartz from a deposit on the south-western 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.

Armand Sicotte & Sons Limited quarries silica near Howick, Quebec for use in elemental phosphorus production at Varennes.

ONTARIO

In mid-1968, Indusmin Limited announced plans to construct a $1.5 million silica grinding and processing plant at Midland. Feed material for the mill is to come from a high-grade silica deposit on Badgeley Island, near Killarney about 120 miles north across Georgian Bay. Early in 1969, the company announced its intention of doubling this investment and now plans to spend an estimated $3.6 million on the grinding plant and related installations at Midland and $2.4 million at the mining site. Construction began early in 1969 and completion is scheduled for March 1970. The Midland processing plant will have an estimated output of 500,000 tons of silica a year. Indusmin acquired the former producing property at Killarney from Union Carbide Canada Limited, adjacent to Badgeley Island where Indusmin is locating the new open-pit silica mine. Primary products from the crushing plant at the Killarney quarry will be shipped both directly to manufacturers of ferrosilicon and silicon metal and to the Midland grinding plant for further processing. Products from the Midland plant will go to the glass, ceramic, chemical and other industries in Ontario.

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 across Lake Winnipeg 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 use as metallurgical flux for The International Nickel Company of Canada, Limited's smelter at Thompson, Manitoba.

BRITISH COLUMBIA

In 1968, Pacific Silica Limited quarried quartz near Oliver. The quartz is crushed, sized and sold as stucco-dash, roofing rock and poultry grit. Part of the production is exported to the United States for use in the manufacture of silicon carbide and ferrosilicon. The quarry was closed permanently during the year but shipments continued from stockpiled material.

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. As 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, ¾ 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 less than 1.5 per cent; lime and magnesia, each less than 0.2 per cent. Phosphorus and arsenic should be absent.

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.

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

High-purity naturally occurring sand or material produced by crushing quartzite or sandstone is used in the manufacture of glass. Generally accepted chemical specifications for silica sand used to manufacture various glass grades, are shown in Table 3.

Minor amounts of certain elements are particularly objectionable as they act as powerful colourants. For example, chromium should not exceed 6 parts per million; cobalt not over 2 parts per million.

TABLE 3

Chemical Specifications for Glass-Grade Silica Sand

Quality	Minimum % SiO_2	Maximum % Al_2O_3	Maximum % Fe_2O_3	Maximum %CaO + MgO
First quality, optical glass	99.8	0.1	0.02	0.1
Second quality, flint glass containers and tableware	98.5	0.5	0.035	0.2
Third quality, flint glass	95.0	4.0	0.035	0.5
Fourth quality, sheet glass rolled, polished plate and window glass	98.5	0.5	0.06	0.5
Fifth quality, sheet glass rolled, polished plate and window glass	95.0	4.0	0.06	0.5
Sixth quality, green glass containers	98.0	0.5	0.3	0.5
Seventh quality, green glass	95.0	4.0	0.3	0.5
Eighth quality, amber glass containers	98.0	0.5	1.0	0.5
Ninth quality, amber glass	95.0	4.0	1.0	0.5

Hydraulic Fracturing

Sand is used in the hydraulic fracturing of oil-bearing strata in order 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 are 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 surfaces is preferred. Grain sizes vary between 20 and 200 mesh. Rounded grains are preferable to angular fragments as round grains allow maximum permeability of the mould and maximum escape 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 for the manufacture of sandpaper. Various grades of sand are used in water-treatment plants as filtering media. Silica is also required in portland cement manufacture where there is insufficient silica in either the limestone or other feed material to the cement plant.

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 concrete autoclave-cured products such as building blocks and panels, in which case, approximately 45 pounds of silica flour is used for each 100 pounds of portland cement consumed.

QUARTZ CRYSTAL

Quartz crystal with desirable piezoelectric properties is used in radio-frequency control apparatus, radar and other electronic devices. Crystal for this purpose must be perfectly transparent and free of 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 come already oriented for the cutter. Purity of these crystals results in final product yields of at least 4 to 1 over natural quartz crystal.

There is only a small demand for quartz crystal in Canada and virtually no production, domestic requirements being met largely by imports chiefly from Brazil and the United States. Quartz Crystals Mines Limited, Toronto, has produced minor tonnages from an occurrence near Lyndhurst, Ontario, however, there has been no production from this mine during the past few years.

TABLE 4

Canada, Available Statistics on Consumption of Silica by Industries, 1966 and 1967

	1966	1967
	Short Tons	Short Tons
Smelter flux*	1,536,683	1,818,810
Glass manufacture (incl. glass fibre)	421,840	478,910
Foundry sand	765,215	670,108
Artificial abrasives	169,177	152,166
Ferrosilicon	163,353	99,270
Metallurgical use	75,667	80,220
Concrete products	60,080	22,706
Gypsum products	53,311	42,968
Asbestos products	34,623	30,975
Chemicals	22,097	23,114
Fertilizers, stock, poultry feed	12,963	32,230
Other	57,659	49,709
Total	3,372,668	3,501,186

Source: Dominion Bureau of Statistics for source data. Classification by Mineral Resources Branch.

*Producers' shipments of quartz and silica for flux purposes.

PRICES

The price of the various grades of silica varies greatly, because it depends upon such factors as location of deposit, the purity and degree of beneficiation required, and market conditions. High-quality silica sand, in carload lots, sells for $8 to $10 per ton in Montreal and Toronto.

TARIFFS

CANADA	Most Favoured Nation	
Ganister and sand	free	
Silex or crystallized quartz, ground or unground	free	
UNITED STATES	On and after Jan. 1, 1968	On and after Jan. 1, 1969
Sand containing by weight 95 per cent or more of silica and not more than 0.6 per cent of oxide of iron—a long ton	45¢	40¢
Other sand	free	free
Quartzite, whether or not manufactured	"	"
Silica, not specially provided for	"	"

Reductions under the Kennedy Round of the General Agreement of Tariffs and Trade (GATT), that was convened in 1964 and concluded in 1967, are scheduled to lower the United States tariff on the first item to 25¢ a long ton on and after January 1st, 1972.

Source: Tariff Schedules of the United States, Annotated 1969, TC publication 272.
The Customs Tariffs and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa.

Silver

J.G. GEORGE*

Canadian mine production of silver in 1968 was 45,621,355 troy ounces, 9.3 million ounces greater than in 1967 and the highest on record. The increase was due mainly to considerably greater byproduct output at the Kidd Creek base-metal mine of Ecstall Mining Limited, a wholly-owned subsidiary of Texas Gulf Sulphur Company near Timmins, Ontario. Declines in Quebec and the Yukon Territory were more than offset by much higher output in Ontario, the leading silver-producing province, together with increases in the other provinces and in the Northwest Territories. Production in the Northwest Territories reached a new all-time high as a result of much higher output by Echo Bay Mines Ltd. from its silver-copper property near Port Radium. Output in the Cobalt-Gowganda area of Ontario was slightly higher than in 1967. The value of Canadian production was $106 million, or almost 69 per cent higher than in 1967, partly due to increased output, but more particularly because of higher silver prices.

The principal source of silver was again base-metal ores, which accounted for more than 90 per cent of total production. Almost 9 per cent came from silver-cobalt ores mined in northern Ontario and the remainder 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, Echo Bay Mines Ltd. in the Northwest Territories, and Noranda Mines Limited (Geco Division) in Ontario. Base-metal ores mined by these four producers accounted for almost 50 per cent of total Canadian silver production. Largest producer in the Cobalt-Gowganda area of Ontario was Hiho Silver Mines Limited with output of 1,137,126 ounces.

Canadian Copper Refiners Limited at Montreal East, Quebec, remained Canada's largest producer of refined silver. It recovered 13,084,000 ounces from the treatment of anode and blister copper. The silver refinery of Kam-Kotia Mines Limited, Refinery Division, at Cobalt, Ontario, was the second largest producer, recovering 12,785,521 ounces in the processing of silver-cobalt ores and concentrates and in the toll refining of silver bullion and coins imported from the United States. Other producers of refined silver were Cominco Ltd. at Trail, British Columbia (from lead and zinc ores and concentrates); The International Nickel Company of Canada, Limited at Copper Cliff, Ontario (from nickel-copper concentrates); Royal Canadian Mint at Ottawa, Ontario (from gold bullion); and Hollinger Mines Limited (formerly Hollinger Consolidated Gold Mines, Limited) at Timmins, Ontario (from gold precipitates). The Hollinger refinery was closed down about mid-1968 when the company's mine and mill suspended operations.

*Mineral Resources Branch.

TABLE 1

Canada, Silver Production, Trade and Consumption, 1967-68

	1967		1968P	
	Troy Ounces	$	Troy Ounces	$
Production*				
By province and territories				
Ontario	14,309,391	24,783,864	22,591,106	52,366,184
British Columbia	6,082,617	10,535,093	6,977,705	16,174,320
Quebec	4,659,232	8,069,790	4,015,827	9,308,687
Northwest Territories	1,980,228	3,429,755	3,855,967	8,938,132
New Brunswick	3,017,416	5,226,165	3,459,000	8,017,962
Yukon	3,869,374	6,701,756	2,061,534	4,778,635
Newfoundland	1,073,153	1,858,701	1,110,000	2,572,980
Manitoba and Saskatchewan	1,234,526	2,138,199	1,304,070	3,022,834
Nova Scotia	89,238	154,560	246,136	570,543
Alberta	14	24	10	23
Total	36,315,189	62,897,907	45,621,355	105,750,300
By sources				
Base-metal ores	31,988,787		41,273,648	
Gold ores	484,619		460,585	
Silver-cobalt ores	3,839,946		3,885,629	
Placer gold ores	1,837		1,493	
Total	36,315,189	62,897,907	45,621,355	105,750,300
Refined silver	20,658,556		26,261,232	
Exports				
In ores and concentrates				
United States	5,304,304	6,500,000	12,138,547	23,364,000
Japan	1,357,349	1,787,000	3,524,213	8,509,000
Belgium and Luxembourg	1,551,913	1,424,000	3,299,029	5,645,000
West Germany	1,343,751	1,789,000	1,092,274	1,351,000
Netherlands	–	–	713,586	995,000
Britain	116,847	117,000	263,041	416,000
Sweden	152,777	211,000	199,226	379,000
Australia	518,173	933,000	–	–
Italy	–	–	124,479	141,000
Norway	32,059	45,000	105,116	136,000
Other countries	30,245	41,000	42,511	91,000
Total	10,407,418	12,847,000	21,502,022	41,027,000
Refined metal				
United States	13,389,938	22,750,000	25,965,955	60,709,000
Belgium and Luxembourg	–	–	1,704,628	3,347,000
Britain	247,856	499,000	288,515	688,000
West Germany	74,790	101,000	119,031	123,000
Venezuela	12,574	24,000	16,103	42,000
Brazil	–	–	6,424	17,000
Trinidad and Tobago	–	–	2,490	5,000
Jamaica	3,987	8,000	1,316	3,000
Other countries	6,530	10,000	100	...
Total	13,735,675	23,392,000	28,104,562	64,934,000

TABLE 1 (Cont'd)

	1967		1968P	
	Troy Ounces	$	Troy Ounces	$
Exports (Cont'd)				
Silverware and goldware n.e.s.				
United States		135,000		124,000
Britain		111,000		95,000
Australia		23,000		31,000
Republic of South Africa		40,000		30,000
Jamaica		20,000		19,000
Bahamas		12,000		17,000
Other countries		48,000		49,000
Total		389,000		365,000
Imports				
Refined metal				
United States	5,371,481	8,211,000	13,403,461	31,551,000
Mexico	–	–	651,182	1,396,000
Britain	11,339	20,000	5,992	12,000
Belgium and Luxembourg	1,052	2,000	–	–
Total	5,383,872	8,233,000	14,060,635	32,959,000
Silverware and goldware, n.e.s.				
United States		1,082,000		961,000
Britain		438,000		311,000
West Germany		262,000		291,000
Hong Kong		32,000		50,000
Italy		68,000		45,000
Japan		26,000		37,000
Other countries		224,000		127,000
Total		2,132,000		1,822,000
Consumption by use				
Coinage	8,791,757		7,352,359	
Silver salts	2,042,778		2,313,346	
Silver alloys	525,169		763,833	
Sterling	1,266,477		841,603	
Wire and rod	12,759		16,666	
Other**	1,937,668		2,310,551	
Total	14,576,608		13,598,358	

Source: Dominion Bureau of Statistics.

*Includes: a) recoverable silver in ores, concentrates and matte shipped for export.
b) silver in crude gold bullion produced.
c) silver in blister and anode copper produced at Canadian smelters.
d) silver in base bullion produced from domestic ores.
e) silver bullion produced from treatment of domestic silver-cobalt ores at Cobalt, Ontario.

**Includes sheet and miscellaneous uses.

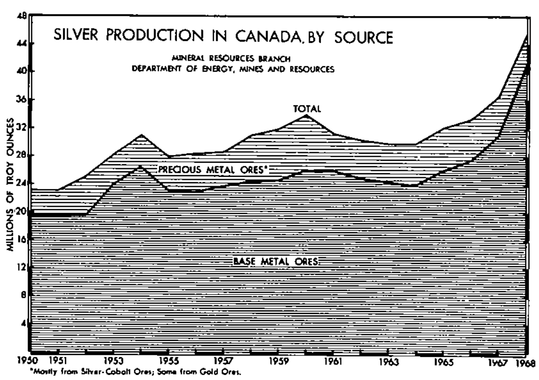
P Preliminary; –Nil;. . . Less than one thousand dollars; n.e.s. Not elsewhere specified.

TABLE 2

Canada, Silver Production, Trade and Consumption, 1959-68
(troy ounces)

	Production		Exports			Imports	Consumption**
	All Forms*	Refined Silver	In Ores and Concentrates	Refined Silver	Total	Refined Silver	Refined Silver
1959	31,923,969	22,362,533	6,814,865	15,140,830	21,955,695	2,807,774	10,202,769
1960	34,016,829	22,564,397	8,897,402	12,761,063	21,658,465	3,849,115	11,742,064
1961	31,381,977	18,239,803	10,352,700	10,783,414	21,136,114	12,278,469	9,614,083
1962	30,422,972	16,749,356	8,861,858	9,445,094	18,306,952	15,182,336	15,419,342
1963	29,932,003	19,772,408	8,286,756	10,834,629	19,121,385	7,950,972	17,574,628
1964	29,902,611	20,744,682	9,478,317	10,583,439	20,061,756	5,197,764	18,775,307
1965	32,272,464	20,630,190	12,245,877	11,268,110	23,513,987	13,413,434	30,170,097
1966	33,417,874	21,298,325	11,850,469	12,221,142	24,071,611	14,477,787	21,303,704
1967	36,315,189	20,658,556	10,407,418	13,735,675	24,143,093	5,383,872	14,576,608
1968p	45,621,355	26,261,232	21,502,022	28,104,562	49,606,584	14,060,635	13,598,358

Source: Dominion Bureau of Statistics.
*Includes recoverable silver (a) in ores, concentrates and matte shipped for export; (b) in crude gold bullion produced; (c) in blister and anode copper produced at Canadian smelters; (d) in base bullion produced from domestic ores; (e) in bullion produced from the treatment of silver-cobalt ores.
**Includes consumption for coinage.
p Preliminary.



Canada's exports of silver in ores and concentrates and as refined metal totalled 49,606,584 ounces in 1968, or more than double the corresponding amount in 1967. The United States continued to be our major market, importing more than 38 million ounces or almost 77 per cent of Canada's total exports. Imports of refined silver in 1968 at 14,060,635 ounces were almost triple those of 1967. More than 95 per cent of the imports came from the United States, with Mexico supplying virtually all of the remainder. The substantial increases in imports and exports of refined metal resulted largely from the refining in Canada of silver bullion and coins imported under arrangement with the Treasury Department of the United States Government. The nationwide strike in the nonferrous industry of the United States had restricted silver refining capacity.

Reported consumption of silver in Canada totalled 13,598,358 ounces, about one million ounces less than in 1967.

WORLD PRODUCTION AND CONSUMPTION

Silver production in the non-communist world in 1968, according to an estimate of Handy and Harman*, was 238.2 million ounces, or 21.4 million ounces more than in 1967. The increase was attributed mainly to higher output in Canada. In 1968, non-communist world consumption for both industrial and coinage uses, excluding requirements for United States coinage which are supplied from Treasury stocks, was 370 million ounces. The gap between production and consumption, not including United States coinage requirements, was some 132 million ounces, considerably less than in 1967.

Consumption of silver for coinage in the non-communist world, excluding the United States, was 22.7 million ounces or about half that in 1967. Sharp reductions in France and Canada accounted for almost half of the decline. The continuing trend toward using

*_The Silver Market_ in 1968, compiled by Handy and Harman.

non-silver coins, or ones of lower silver content, has brought about reduced demand for this purpose. In August 1968, Canada began production of pure nickel coins in all denominations, namely 5-, 10-, 25-, 50-cent and one dollar coins. Other countries that abandoned silver as a coinage metal in 1968 and replaced it with pure nickel or base-metal alloys included Sweden, Switzerland, Egypt, the Dominican Republic, Macao, the Netherlands and Brazil.

Based on preliminary figures, Canada in 1968 became the world's largest mine producer of silver; other leading producers were Mexico, Peru and the United States.

TABLE 3

World Production of Silver 1967-68
(troy ounces)

	1967	1968[e]
Canada	36,426,079	41,000,000*
Mexico	37,939,498	39,000,000
Peru	35,869,829	37,000,000
Russia	35,000,000[e]	..
United States	32,118,694	31,400,000
Australia	19,765,000	..
Japan	10,833,532	..
East Germany	4,800,000[e]	..
Bolivia (exports)	4,275,368	..
Honduras	4,009,418	..
Sweden	4,000,000[e]	..
Yugoslavia	3,075,472	..
Chile	3,065,504	..
Republic of South Africa	3,063,505	..
Other countries	26,578,101	120,000,000
Total	260,820,000[e]	268,400,000

Sources: 1967 statistics from U.S. Bureau of Mines Minerals Yearbook, 1967.
1968 statistics from U.S. Bureau of Mines Commodity Data Summaries, January, 1969.
* According to Dominion Bureau of Statistics, production was 45,621,355 ounces.
[e] Estimated; .. Not available.

New production of silver in the United States decreased slightly from 32.1 million ounces in 1967 to an estimated 31.4 million ounces in 1968. In the United States, the world's largest silver consumer, consumption for industrial uses and coinage was 145.0 and 36.8 million ounces, respectively, in 1968. The large deficit in requirements was again met by withdrawals from United States Treasury stocks, demonitized coinage, secondary silver and liquidation of speculative holdings. Requirements for United States coinage were again obtained from Treasury stocks which were reduced during 1968 from 351 to 69 million ounces, excluding silver in recovered coins. The United States Mint used 36.8 million ounces of silver for coinage in 1968 compared with 43.8 million ounces in 1967.

The dominant feature in the silver market during 1968 was the magnitude of the price fluctuations. After declining in the early part of the year, the New York price then rose to an all-time high of $2.565 an ounce in mid-June. From then until the end of the year the price trend was generally downward with frequent and substantial fluctuations. The London silver price closely followed its United States counterpart. A major factor contributing to the rise and fall in prices in 1968 was the large-scale buying and selling by speculators and investors. Another factor accounting for the drop in the silver price was the reported sale on the international market of some 60 million ounces from the Far and Near Eastern countries.

CANADIAN DEVELOPMENTS

YUKON TERRITORY AND NORTHWEST TERRITORIES

The substantial decrease in silver output in 1968 in the Yukon Territory resulted mainly from a further curtailment in mining and milling operations at United Keno Hill Mines Limited. Because of declining ore reserves, its concentrator was operated on a single-shift basis. A new shaft was sunk to a depth of 423 feet below the surface collar on the company's Husky claims which are being explored and developed in the vicinity of the Elsa mine. The headframe and shaft house, the hoist-compressor plant and the boiler house were erected. In the second half of 1968, Arctic Gold and Silver Mines Limited (formerly Arctic Mining and Exploration Limited) began tune-up operations at its Arctic Caribou silver-gold property and 300-ton-a-day mill near Carcross, Y.T. In September 1968, tune-up operations began at the gold-silver property and 400-ton-a-day concentrator of Mount Nansen Mines Limited near Carmacks, Y.T. The company, controlled by Peso Silver Mines Limited, also began installation of a cyanide circuit to provide better recovery of gold and silver from the more oxidized ores in the Webber veins.

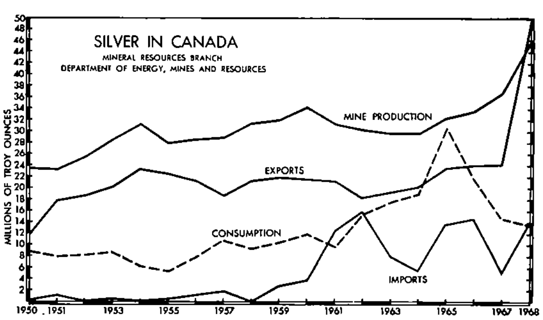
Anvil Mining Corporation Limited continued construction of its 5,500-ton-a-day mill to treat zinc-lead-silver ore from its Faro open-pit mine near Ross River, Y.T. The ore contains about one ounce of silver a ton. Initial production is scheduled for late 1969 and, when the mill reaches full capacity, annual silver output could amount to some 2 million ounces. Extensive underground development work was carried out on the gold-silver-lead-zinc property of Venus Mines Ltd. about 18 miles south of Carcross, Y.T. The company was considering bringing the property into production and erecting a mill with a 300-ton-a-day capacity.

In the Northwest Territories almost all the silver output was produced by Echo Bay Mines Ltd., which operates a silver-copper property near Port Radium on the east shore of Great Bear Lake. In 1968, when the company became a subsidiary of International Utilities Corporation, it was Canada's third largest mine producer of silver. Terra Mining and Exploration Limited continued exploration and development work at its silver-copper property in the Camsell River area about 27 miles southwest of Port Radium. The company was planning to erect a 100-ton-a-day concentrator and bring the property into production late in 1969.

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. Utica Mines Ltd. completed its first full year's operation at its silver-gold mine near Keremeos, and produced over one million ounces of silver. Mastodon-Highland Bell Mines Limited produced more than one-half million ounces of silver at its silver-lead-zinc property at Beaverdell.

A feasibility study regarding the silver property of Dolly Varden Mines Ltd. near Alice Arm suggested the possibility of a 500-ton daily operation. The preliminary figures, released in May 1968, were based on ore reserves, in the categories of semi-proven, probable and possible, totalling 1,288,800 tons grading 8.8 ounces silver a ton plus appreciable amounts of lead, zinc and cadmium. Underground exploration and development work continued at the silver-lead-zinc property of Interprovincial Silver Mines Ltd. northeast of Atlin near the Yukon border. The company was planning on building a 200-ton-a-day concentrator and bringing its property into production by late 1969. Exploration and development work continued at the silver-lead-zinc property of Silmonac Mines Limited about 40 miles northwest of Nelson in the Kootenay District.



MANITOBA–SASKATCHEWAN

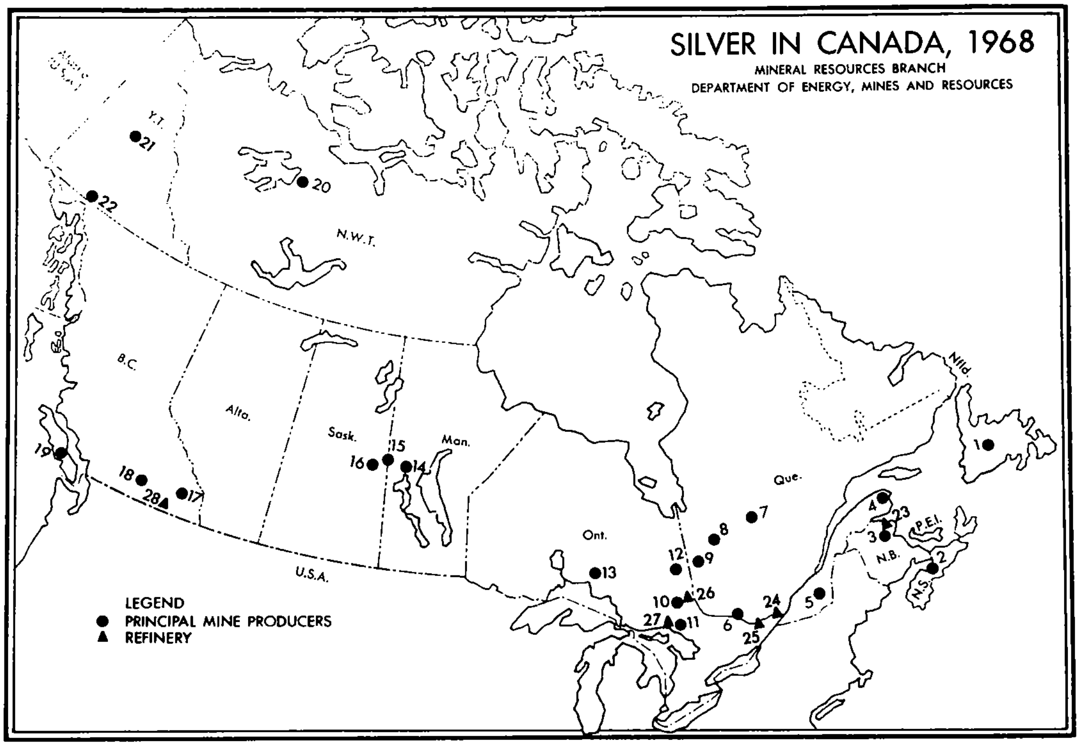
In Manitoba and Saskatchewan most of the silver output again came from base-metal mines near Flin Flon and Snow Lake, Man., operated by Hudson Bay Mining and Smelting Co., Limited. The company operated five mines, including the Osborne Lake mine near Snow Lake which was brought into production in July 1968. The company continued development of the Anderson Lake mine near Snow Lake and the Flexar mine 8½ miles southwest of Flin Flon.

ONTARIO

Ontario was again the leading silver-producing province with its output accounting for almost 50 per cent of Canadian production. This was attributable for the most part to much greater byproduct output at the Kidd Creek base-metal mine of Ecstall Mining Limited, near Timmins, which was almost 5.6 million ounces greater than in 1967. Nearly four million ounces were again derived from silver-cobalt mines in the Cobalt-Gowganda area of northern Ontario. A large part of the remainder was byproduct production of Noranda Mines Limited (Geco Division) in the Manitouwadge area and The International Nickel Company of Canada, Limited at Sudbury.

As a result of the higher silver prices that have obtained since mid-1967, more of the companies operating in the Cobalt-Gowganda district are taking a closer look at the possible retreatment of old mill tailings. In 1968, Siscoe Metals of Ontario Limited entered into an agreement with Manridge Mines Limited to lease the latter's mineral property holdings in the Township of Milner about 12 miles from the Siscoe mine. Surface diamond drilling conducted previously under the direction of Zenmac Metal Mines Limited, as well as drilling done by Siscoe Metals in the fall of 1968, indicated sufficient silver ore of economic value to justify underground development and production from the property. The required surface plant and buildings are now under construction and an old shaft is being rehabilitated. It was expected that operations would begin in the second half of 1969 with the ore to be trucked to the Siscoe mill for processing.

Willroy Mines Limited, under the terms of its leasing agreement with Big Nama Creek Mines Limited, began preparing the latter's copper-zinc-lead-silver orebody for production. It was expected that mining operations would begin late in 1969 with the ore to be milled at the Willroy concentrator. The Big Nama deposit adjoins the Willroy mine on the northwest. Exploration and development work continued at the silver-gold-lead-zinc prospect of Golsil Mines Limited in the Favourable Lake area, about 100 miles north of Red Lake.



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 (Nos. 12 and 6 mines)
   Heath Steele Mines Limited
   Nigadoo River Mines Limited
4. Gaspé Copper Mines, Limited
5. Cupra Mines Ltd.
   Solbec Copper Mines, Ltd.
6. New Calumet Mines Limited
7. Campbell Chibougamau Mines Ltd.
   Opemiska Copper Mines (Quebec) Limited
8. Mattagami Lake Mines Limited
9. Lake Dufault Mines, Limited
   Manitou-Barvue Mines Limited
   Noranda Mines Limited (Horne mine)
   Normetal Mines Limited
   Quemont Mines Limited
10. Agnico Mines Limited
    Deer Horn Mines Limited
    Glen Lake Silver Mines Limited
    Hiho Silver Mines Limited
    Langis Silver & Cobalt Mining Company Limited
    Silverfields Mining Corporation Limited
    Silver Town Mines Limited
    Siscoe Metals of Ontario Limited
11. The International Nickel Company of Canada, Limited
12. Ecstall Mining Limited
13. Noranda Mines Limited (Geco Division)
    Willecho Mines Limited
    Willroy Mines Limited
14. Hudson Bay Mining and Smelting Co., Limited (Chisel Lake, Stall Lake, and Osborne Lake mines)
15. Hudson Bay Mining and Smelting Co., Limited (Flin Flon and Schist Lake mines)
16. Western Nuclear Mines, Ltd.
17. Cominco Ltd. (Sullivan and Bluebell mines)
18. Mastodon-Highland Bell Mines Limited
    Utica Mines Ltd.
19. Western Mines Limited
20. Echo Bay Mines Ltd.
21. United Keno Hill Mines Limited
22. Arctic Gold and Silver Mines Limited

REFINERIES

23. East Coast Smelting and Chemical Company Limited
24. Canadian Copper Refiners Limited
25. Royal Canadian Mint
26. Kam-Kotia Mines Limited (Refinery Division)
27. The International Nickel Company of Canada, Limited
28. Cominco Ltd.

TABLE 4

Principal Silver Producers in Canada, 1968

Company and Location	Mill Capacity (short tons ore/day)	Type of Ore Milled	Silver Grade 1968 (1967) (oz/ton)	Ore Produced 1968 (1967) (short tons)	Contained Silver Produced 1968 (1967) (troy ounces)	Remarks
YUKON TERRITORY – NORTHWEST TERRITORIES						
Arctic Gold and Silver Mines Limited (formerly Arctic Mining and Exploration Limited), Carcross, Y.T.	300	Ag, Au	8.35 (–)	30,811 (–)	185,637 (–)	Mill began operations May 1968.
Echo Bay Mines Ltd., Port Radium, N.W.T.	150	Ag, Cu	68.12 (. .)	36,985 (. .)	2,669,880 (. .)	3–compartment shaft completed to depth of 500 feet below 3rd adit level, and two levels driven to ore zones.
United Keno Hill Mines Limited, Calumet and Elsa mines, Mayo District, Y.T.	500	Ag, Pb, Zn	33.93 (37.69)	60,800 (106,189)	1,981,777 (3,804,644)	New shaft on Husky claim sunk to 423 feet below the surface collar.
BRITISH COLUMBIA						
Cominco Ltd., Sullivan mine, Kimberley	10,000	Pb, Zn, Ag	. . (. .)	2,155,749 (2,118,377)	3,140,650 (3,302,047)	Cominco's total silver output was 6,936,485 ounces.
Bluebell mine, Riondel	700	Pb, Zn, Ag	. . (. .)	251,497 (255,536)	. . (. .)	Routine exploration and development
Mastodon-Highland Bell Mines Limited, Beaverdell	115	Ag, Pb, Zn	15.45 (20.99)	36,413 (34,020)	562,560 (713,911)	Bell and Beaver workings rehabilitated for future exploration and mining.
Utica Mines Ltd., Keremeos	350	Ag, Au, Pb, Zn	. . (. .)	128,652 (38,442)	1,067,971 (422,158)	Completed first full year of operations.
Western Mines Limited,[1] Myra Falls, Vancouver Island	1,000	Zn, Cu, Pb, Ag	2.15 (2.0)	330,223 (230,036)	. . (. .)	New ore developed in 1968 fiscal year was almost sufficient to replace quantity mined.

TABLE 4 (Cont'd)

Company and Location	Mill Capacity (short tons ore/day)	Type of Ore Milled	Silver Grade 1968 (1967) (oz/ton)	Ore Produced 1968 (1967) (short tons)	Contained Silver Produced 1968 (1967) (troy ounces)	Remarks
MANITOBA – SASKATCHEWAN						
Hudson Bay Mining and Smelting Co., Limited	6,000 (treated at central mill at Flin Flon)	Cu, Zn, Pb, Ag	0.7 (0.76)	1,614,100 (1,588,164)	942,200 (971,443)	Osborne Lake mine brought into production July 1968.
Flin Flon mine, Flin Flon, Man.		Cu, Zn, Ag, Pb	0.8 (0.71)	806,500 (943,811)		
Chisel Lake mine, Snow Lake, Man.		Zn, Cu, Pb, Ag	1.1 (1.17)	278,400 (254,118)		
Stall Lake mine, Snow Lake, Man.		Cu, Zn, Ag	0.4 (0.34)	230,800 (268,729)		
Osborne Lake mine, Snow Lake, Man.		Cu, Zn, Ag	0.1 (–)	177,400 (–)		
Schist Lake mine, Flin Flon, Man.		Cu, Zn, Ag	1.4 (1.24)	121,000 (121,506)		
Western Nuclear Mines, Ltd., Hanson Lake mine, Hanson Lake, Sask.	350	Zn, Pb, Cu, Ag	2.89 (5.25)	60,789 (41,898)	159,557 (75,662)	Routine exploration and development.
ONTARIO						
Ecstall Mining Limited (Texas Gulf Sulphur Company), Kidd Creek mine, Timmins	9,000	Zn, Cu, Ag, Pb	5.19 (3.0)	3,614,860 (3,039,219)	13,396,190 (7,800,000)	Metallurgical recovery of silver improved.
Noranda Mines Limited (Geco Division), Manitouwadge	4,000	Cu, Zn, Ag, Pb	2.20 (2.02)	1,495,369 (1,461,000)	2,452,360 (2,193,940)	Company plans surface diamond drilling on north part of its property.
Willecho Mines Limited, Lun-Echo mine, Manitouwadge	ore custom-milled	Zn, Cu, Ag, Pb	2.15 (1.91)	346,444 (338,437)	402,680 (359,992)	Ore treated at Willroy mill. Company completed conveyor installation for lower levels.

TABLE 4 (Cont'd)

Company and Location	Mill Capacity (short tons ore/day)	Type of Ore Milled	Silver Grade 1968 (1967) (oz/ton)	Ore Produced 1968 (1967) (short tons)	Contained Silver Produced 1968 (1967) (troy ounces)	Remarks
Willroy Mines Limited, Manitouwadge	1,700	Cu, Zn, Ag, Pb	0.77 (1.25)	174,336 (165,053)	71,898 (114,431)	Exploration drive on Slimlake property advanced 1,643 feet. Began underground development of Big Nama Creek orebody.
The International Nickel Company of Canada, Limited, Sudbury, Ont., and Thompson, Man.	76,500	Ni, Cu	.. (..)	24,350,000 (20,410,000)	1,607,000[2] (1,592,000)[2]	Combined capacity and output for Sudbury and Thompson mills.
Agnico Mines Limited, Agnico 407 mine, Cobalt District	400	Ag, Co	14 (17.69)	33,384[3] (37,315)[3]	581,466 (668,921)	No. 96 shaft deepened 293 feet.
Deer Horn Mines Limited, Cross Lake property, Cobalt District	100	Ag, Co	8.4 (12.4)	21,881 (11,224)	184,351 (132,794)	Routine exploration and development.
Glen Lake Silver Mines Limited, Cobalt District	150	Ag, Co	7.59 (28.31)	9,085 (5,397)	48,999 (152,770)	Developing area between Conisil and Giroux Lake shafts.
Hiho Silver Mines Limited, Cobalt District	250	Ag, Co	11.63 (25.80)	97,704 (34,273)	1,137,126 (874,709)	Surface and underground drilling continued at Kerr Lake property.
Langis Silver & Cobalt Mining Company Limited, Langis mine, Cobalt District	175	Ag, Co	8.14 (10.09)	15,705 (31,244)	111,387 (276,292)	Ore produced includes portion of old mill tailings treated. Mining and milling operations suspended July 31, 1968.
Silverfields Mining Corporation Limited, Cobalt District	250	Ag, Co	12.6 (17.40)	80,705 (65,275)	996,960 (1,132,622)	Began development on lowest (6th) level.
Silver Town Mines Limited, Cobalt District	ore custom-milled	Ag, Co	14.38 (23.42)	8,024[4] (6,022)	180,443 (148,781)	Drained east bay of Peterson Lake to recover old mill tailings.
Siscoe Metals of Ontario Limited, Gowganda District	275	Ag, Co	20.92 (18.55)	47,544 (50,917)	963,564 (917,333)	Routine exploration and development.

TABLE 4 (Cont'd)

Company and Location	Mill Capacity (short tons ore/day)	Type of Ore Milled	Silver Grade 1968 (1967) (oz/ton)	Ore Produced 1968 (1967) (short tons)	Contained Silver Produced 1968 (1967) (troy ounces)	Remarks
QUEBEC						
Campbell Chibougamau Mines Ltd.,[5] Main, Cedar Bay and Henderson mines, Dore Lake, Chibougamau District	3,500	Cu, Au, Ag	0.228 (0.266)	1,003,064 (980,536)	169,437 (194,242)	Routine exploration and development.
Cupra Mines Ltd., Cupra mine, Stratford Centre	1,500	Cu, Zn, Pb, Ag	1.21 (1.344)	225,702 (308,347)	198,533 (346,077)	Routine exploration and development.
Gaspé Copper Mines, Limited, Gaspé mine, Murdochville	11,250	Cu, Mo	.. (..)	3,933,745 (2,763,085)	370,628 (431,572)	Combined capacity and output for Needle Mountain and Copper Mountain concentrators.
Lake Dufault Mines, Limited, Noranda	1,300	Cu, Zn, Ag	1.24 (2.53)	415,009 (492,938)	400,038 (941,302)	Began sinking new Millenbach shaft and reached depth of 480 feet by end of 1968.
Manitou-Barvue Mines Limited, Golden Manitou mine, Val d'Or	1,300	Cu, Zn, Au, Ag	0.81 (1.34)	181,250[6] (181,350)[6]	127,481 (202,000)	Developing new silver-zinc zone east of old mine workings.
Mattagami Lake Mines Limited, Mattagami Lake mine, Matagami	3,850	Zn, Cu, Ag, Au	0.80 (0.85)	1,363,705 (1,414,136)	.. (..)	Routine exploration and development.
New Calumet Mines Limited, Calumet Island	800	Zn, Pb, Ag	4.18 (4.33)	70,476 (90,779)	238,795 (322,018)	Mining and milling operations ceased October 31, 1968.
Noranda Mines Limited, Horne mine, Noranda	3,200	Cu, Au	0.382 (..)	773,765 (855,534)	142,491 (164,779)	Company's exploration groups continuing exploration programs.
Normetal Mines Limited (formerly Normetal Mining Corporation, Limited), Normetal mine, Normetal	1,000	Zn, Cu, Ag	1.79 (1.55)	358,557 (348,440)	436,352 (350,620)	Routine exploration and development.
Opemiska Copper Mines (Quebec) Limited, Chapais	2,000	Cu, Au, Ag	0.39 (0.43)	744,466 (737,272)	248,230 (267,107)	Developing Perry mine between 2,000- and 3,300-foot levels; developing Robitaille mine.
Quemont Mines Limited (formerly Quemont Mining Corporation, Limited), Noranda	2,300	Cu, Zn, Au, Ag	0.79 (0.78)	429,309 (443,774)	210,109 (202,471)	Routine development of remaining ore reserves.

TABLE 4 (Cont'd)

Company and Location	Mill Capacity (short tons ore/day)	Type of Ore Milled	Silver Grade 1968 (1967) (oz/ton)	Ore Produced 1968 (1967) (short tons)	Contained Silver Produced 1968 (1967) (troy ounces)	Remarks
Solbec Copper Mines, Ltd. Stratford Centre	ore custom-milled	Cu, Zn, Pb, Ag	1.85 (1.694)	262,076 (75,310)	269,968 (77,932)	Routine exploration and development. Ore treated at Cupra mill.
NEW BRUNSWICK						
Brunswick Mining and Smelting Corporation Limited,						
No. 12 mine, Bathurst	5,000	Zn, Pb, Cu, Ag	1.92 (2.39)	1,724,465 (1,669,000)	2,023,148 (2,100,478)	Operations at company's mining, milling and smelter complex continued to improve.
No. 6 mine, Bathurst	2,500	Zn, Pb, Cu, Ag	1.53 (1.79)	984,280 (867,400)	901,180 (806,775)	
Heath Steele Mines Limited, Newcastle	1,500[7]	Zn, Cu, Pb, Ag	. . (2.64)	391,363 (308,866)	373,454 (479,066)	Began utilizing total mill capacity to treat company's own ores.
Nigadoo River Mines Limited, Bathurst	1,000	Pb, Zn, Cu, Ag	3.33 (3.22)	284,867 (22,630)	694,486 (51,415)	Completed first full year of operations.
NOVA SCOTIA						
Dresser Minerals, Division of Dresser Industries, Inc., Walton	125	Ag, Pb, Cu, Zn	7.10 (7.4)	49,786 (50,330)	270,832 (283,901)	Continued normal underground exploratory diamond drilling.
NEWFOUNDLAND						
American Smelting and Refining Company (Buchans Unit), Buchans	1,250	Zn, Pb, Cu, Ag	3.93 (4.04)	378,000 (378,000)	1,354,860 (1,326,711)	Routine exploration and development.

Source: Company reports.
[1]Production for fiscal years ending September 30. [2]Silver delivered to markets. [3]Production does not include old mill tailings treated in separate 1,000-ton-a-day reclamation plant. In 1968, 81,530 tons of tailings grading about 3 ounces silver a ton were treated. [4]Production does not include old mill tailings custom-milled in separate concentrator. In 1968, 24,542 tons of tailings grading 3.4 ounces silver a ton were processed. [5]Production for fiscal years ending June 30. [6]Production does not include copper ore milled in separate circuit. [7]Part of Heath Steele's mill capacity used to treat copper ore from nearby Wedge mine operated by Cominco Ltd.
– Nil; . . Not available.

QUEBEC

Silver output in the province, derived almost entirely from gold and base-metal ores, was somewhat lower in 1968 than in 1967. A large portion of the decrease resulted from much lower byproduct production by Lake Dufault Mines, Limited, near Noranda, because of the lower grade and decreased tonnage of ore processed in 1968. Diamond drilling and exploration work in the upper eastern part of the base-metal mine of Manitou-Barvue Mines Limited near Val d'Or has indicated ore reserves of 335,000 tons. Grade of the new ore is 6.2 ounces of silver and 0.013 ounce of gold a ton, 2.19 per cent zinc and 0.47 per cent lead, after allowing for 15 per cent dilution.

Shaft sinking and other development work continued at the base-precious metals property of D'Estrie Mining Company Ltd. at Stratford Centre in the Eastern Townships. The company, controlled by the Sullivan group of companies, planned to bring the property into production late in 1969 with the ore to be milled at the nearby Cupra concentrator. A feasibility study carried out concerning the base-precious metals property of Delbridge Mines Limited, near Noranda, indicated it could be brought into production on a profitable basis. Previous diamond drilling indicated reserves of 326,000 tons above the 1,050-foot level grading 11.97 per cent zinc, 1.03 per cent copper, 4.15 ounces of silver and 0.09 ounce of gold a ton. Delbridge is owned 51 per cent by Falconbridge Nickel Mines, Limited and 49 per cent by D'Eldona Gold Mines Limited. Exploration work continued at the copper-zinc-silver property of Conigo Mines Limited about 3 miles northwest of Amos. Approximately 40,000 feet of diamond drilling has been completed and the company is considering sinking a shaft to a depth of 2,000 feet to enable it to begin underground development work.

NEW BRUNSWICK

After completing its first full year of operations, Nigadoo River Mines Limited became a substantial producer of byproduct silver. The company, whose mine and 1,000-ton-a-day concentrator are located about 15 miles northwest of Bathurst, is controlled by the Sullivan group of companies. Ore production increased substantially, as a result of a mine development and shaft sinking program, at the zinc-copper-lead-silver property of Heath Steele Mines Limited, 40 miles northwest of Newcastle. Treatment of custom ore from another nearby mine ceased in May 1968 and Heath Steele replaced this ore with production from its own mine. Exploration studies in 1968 confirmed sufficient ore reserves to double the mine production rate to 1,000,000 tons of combined zinc-copper-lead-silver ore a year and to sustain this rate for at least 20 years. Construction and installation of equipment required for this expansion was scheduled for completion in 1969.

Further metallurgical test work was carried out at the lead-zinc-silver property of Restigouche Mining Corporation, Ltd., about 70 miles west of Bathurst, to improve concentrate grade and recovery. The company was negotiating for suitable terms of purchase for the expected output of concentrates and, if successful, it planned to bring the property into production at a rate of 1,000 tons a day. The deposit contains 3,270,000 tons grading 2.45 ounces of silver a ton.

USES

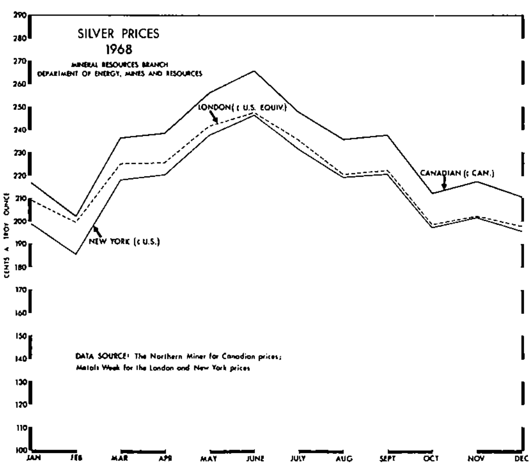
Although the number of industrial applications for silver has increased, substantial quantities of the metal are still used in the manufacture of coinage. This is because it strongly resists corrosion, has good alloying properties, and has an attractive appearance and intrinsic value. The quantity of silver required for coinage, however, declined again because of the continuing trend toward using silverless coins or ones of reduced silver content. According to Handy and Harman, non-communist world consumption of silver for coinage dropped from a high of 381.1 million troy ounces in 1965 to 59.5 million ounces in 1968. 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 use.

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.

PRICES

The New York silver price followed a very erratic pattern during 1968 as illustrated by the graph on this page. The year opened with the price at $2.150 a troy ounce, but it declined steadily from the beginning of the year until February 13 when it reached a low of $1.81 for the year. From then until mid-June the price displayed an upward trend with frequent variations. A record high of $2.565 was reached on June 12. During the remainder of the year the price trend was generally downward but, again, with frequent and substantial fluctuations, and at year-end it was $1.90. The London price ranged between a high of 259.0 pence a troy ounce, equivalent to $2.576 (US), on June 12 and a low for the year of 185.0 pence, equivalent to $1.842 (US), on October 17.

In 1968, the Canadian silver price closely followed its United States counterpart with the essential difference being the exchange rate; it ranged between a low of $1.973 a troy ounce on February 13 and an all-time high of $2.768 on June 12.



TARIFFS*

CANADA	Most Favoured Nation
Ores of metal, n.o.p.	free
Anodes of silver	free
Silver in ingots, blocks, bars, drops, sheets or plates, unmanufactured; silver sweepings	free
Silver leaf	23%
Articles consisting wholly or in part of sterling or other silverware, n.o.p.; manufactures of silver, n.o.p.	25½%

UNITED STATES	
Precious metal ores, silver content	free
Silver bullion, dore, and silver precipitates	free
Silver (including platinum – or gold-plated silver but not rolled silver), unwrought (except bullion, dore, and precipitates) or semi-manufactured:	
Platinum-plated	26%
Gold-plated	40%
Other	16.5%
Rolled silver	16.5%
Precious metal sweepings and other precious metal waste and scrap	
Silver content	free

Sources: The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa.
Tariff Schedules of the United States Annotated (1969) TC Publication 272.

*On and after January 1, 1969.

n.o.p. – not otherwise provided for.

Sodium Sulphate

W.E. KOEPKE*

Canada's sodium sulphate industry has expanded sharply in the past decade to meet the requirements of the kraft pulp and paper industry, which is by far the largest single consumer of sodium sulphate (Na_2SO_4) in North America. Sodium sulphate, commonly known as 'salt cake', can be produced: (1) from natural deposits and brines in alkaline lakes that occur in areas of little or no drainage and dry climates; (2) from subsurface deposits and brines; or (3) 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 also recovered at a viscose-rayon plant in eastern Canada. North America's other major sodium sulphate producing areas are in California, Texas and Wyoming for the natural type, and the eastern States for the byproduct type.

The industry in western Canada supplies over 90 per cent of this country's sodium sulphate needs; in addition, the level of production has generally been sufficient to allow for the export of one quarter to one third the total output. Production increased at an average annual rate of about 11 per cent in the decade 1959 to 1968. Exports had increased at a similar rate throughout most of the last ten years but declined considerably in 1968. Sodium sulphate imports, which have remained fairly constant over the past 15 years and now constitute less than 10 per cent of Canada's consumption, generally are of slightly higher grade than domestic output and serve those markets not readily accessible from Saskatchewan. Nearly all of Canada's sodium sulphate trade is with the United States.

*Mineral Resources Branch.

PRODUCTION AND DEVELOPMENTS IN CANADA

Production of sodium sulphate in Canada increased for the sixth consecutive year in 1968 to reach 469,076 tons valued at $7.4 million, a tonnage increase of 11 per cent from 1967 and almost double that of 1960. The entire output came from alkaline lakes in southern Saskatchewan, although in 1969 some production is expected in Alberta. A small quantity of byproduct salt cake (estimated at 15,000 tons in 1968) is recovered at a viscose-rayon plant in Ontario, but this is not included in Canada's sodium sulphate production statistics.

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.

TABLE 1

Canada, Sodium Sulphate Production and Trade, 1967-68

	1967		1968p	
	Short Tons	$	Short Tons	$
Production (shipments)	428,316	6,359,039	469,076	7,403,494
Imports				
Total crude salt cake and Glauber's salt				
United States	17,725	394,000	23,105	565,000
Belgium and Luxembourg	3,601	68,000	1,821	35,000
Japan	–	–	55	3,000
Other countries	6,295	110,000	36	1,000
Total	27,621	572,000	25,018	604,000
Exports				
Crude sodium sulphate				
United States	120,760	2,020,000	104,153	2,290,000
Australia	3,073	73,000	4,831	114,000
Total	123,833	2,093,000	108,984	2,404,000

Source: Dominion Bureau of Statistics.
pPreliminary; – Nil.

The sodium sulphate deposits in Saskatchewan and the bordering areas of Alberta have formed in shallow undrained lakes and ponds where runoff waters carry dissolved sulphate in 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 ($Na_2SO_4.10H_2O$). 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.

Reserves in Saskatchewan have been estimated at 100 million tons of anhydrous sodium sulphate, of which about one half is considered economically recoverable at current prices and technology. Ten deposits in Saskatchewan each contain reserves ranging from 2 million to as much as 9 million tons. One deposit in Alberta contains an estimated 1.8 million tons of Na_2SO_4.

RECOVERY AND PROCESSING

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.

TABLE 2

Canada, Sodium Sulphate Production, Trade and Consumption, 1959-68
(short tons)

	Production*	Imports**	Exports	Consumption
1959	179,535	28,123	47,922	171,634
1960	214,208	25,857	63,831	183,062
1961	250,996	33,209	87,048	200,096
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	336,346r
1967	428,316	27,621	123,833	357,761e
1968p	469,076	25,018	103,984	407,600e

Source: Dominion Bureau of Statistics.
*Producers' shipments of crude sodium sulphate
**Includes Glauber's salt and crude salt cake
pPreliminary; rRevised; eEstimated

Sodium sulphate recovery generally begins with the pumping of 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 plant. Another company is planning to use a type of swamp buggy for both removal and transport of the raw material to the plant area. Plans for an Alberta plant starting up in 1969 are to recover the raw material from the lake in the form of a hot solution.

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 and 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.

Processing consists essentially of the dehydration of the natural crystal (Glauber's salt contains 55.9 per cent H_2O by weight) and drying. Processing equipment includes submerged combustion units, evaporators, classifiers, centrifuges, rotary kiln-dryers, screens, and crushers. The end-product, a powdery white substance commonly known as salt cake, grades a minimum of 97 per cent Na_2SO_4. Product purity of 99.77 per cent Na_2SO_4 has been achieved. Uniform grain size and free-flowing characteristics are important in material handling and use.

CURRENT OPERATIONS

There were eight sodium sulphate plants operating in Saskatchewan at the end of 1968 (see Table 3). Six plants – at Palo, Ormiston, Chaplin, Bishopric, Fox Valley, and Gladmar – collectively operated throughout the year at about three-quarters capacity. Because of the seasonal nature of harvesting sodium sulphate, plant capacities tend to be larger than annual operating rates.

At Alsask, where plant operation began in mid-1967, some difficulty was experienced in obtaining an adequate fresh water supply and production rates were lower than anticipated. The company is contemplating the use of mechanical equipment to supplement the brining system.

The plant at Cabri was brought into production late in 1968 and was officially opened in January 1969. It is operated by Francana Minerals Ltd., which is owned by Tombill Mines Limited and Hudcana Development Corporation Ltd., the latter being controlled by Hudson Bay Mining and Smelting Co., Limited. In preparation for plant start-up, Francana began brining at Snakehole Lake in 1967 and stockpiling early in 1968. The company has also constructed facilities at nearby Verlo Lakes to supplement its raw material needs. The Cabri plant has been estimated to cost $2.5 million and is designed to produce 100,000 tons of sodium sulphate annually.

A ninth plant is being built near Metiskow, Alberta, and will be operated by Alberta Sulphate Limited, a partnership of Chemcell Limited and Western Minerals Ltd. The $2.5-million plant will have an annual productive capacity of 100,000 tons of sodium sulphate and is expected to begin operation in mid-1969. Horseshoe Lake will be the source lake and recovery of the raw material from the lake will be in the form of a hot solution.

Courtaulds (Canada) Limited produces about 15,000 tons of byproduct salt cake annually from the operation of a viscose-rayon plant at Cornwall, Ontario.

CANADIAN CONSUMPTION AND TRADE

About 95 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. The kraft process also lends itself to greater ease in controlling pollution at pulp mills. There were 38 kraft pulp mills operating in Canada at the end of 1968 – fifteen in British Columbia, nine in Quebec, eight in Ontario, three in New Brunswick, and one each in Nova Scotia, Saskatchewan and Alberta. Consumption of sodium sulphate in the pulp and paper industry has increased from 168,000 tons in 1959 to an estimated 390,000 tons in 1968, for an average annual growth rate of 8.8 per cent.

TABLE 3
Canada, Sodium Sulphate Producers, 1968

Company	Plant Location*	Source Lake*	Capacity tpy
Francana Minerals Ltd.	Cabri	Snakehole	100,000
Midwest Chemicals Limited	Palo	Whiteshore	120,000
Ormiston Mining and Smelting Co. Ltd.	Ormiston	Horseshoe	100,000
Saskatchewan Minerals	Chaplin	Chaplin	150,000
" "	Bishopric	Frederick	70,000
" "	Fox Valley	Ingebrigt	150,000
Sodium Sulphate (Saskatchewan) Ltd.	Alsask	Alsask	50,000
Sybouts Sodium Sulphate Co.; Ltd.	Gladmar	East Coteau	50,000
Total			790,000

* All in the Province of Saskatchewan.

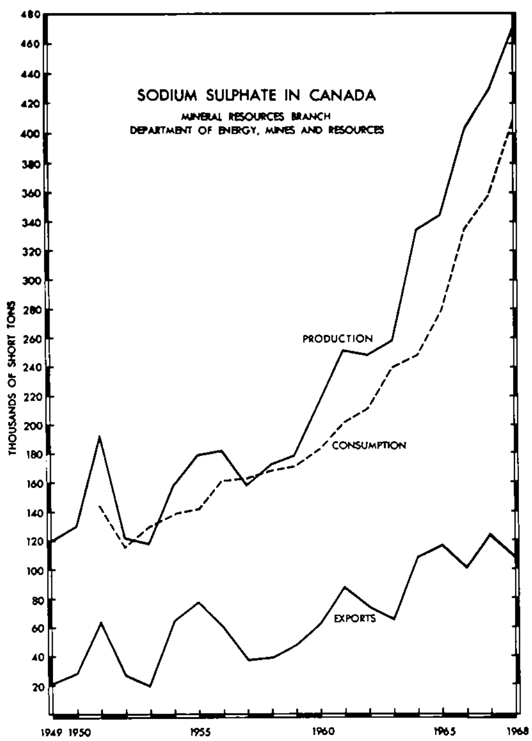


TABLE 4

Canada, Available Data on Sodium Sulphate Consumption, 1966-68
(short tons)

	1966	1967	1968[e]
Pulp and paper	323,911[r]	340,000[e]	390,000
Glass and glasswool	4,311	5,994	6,000
Soaps	5,067	6,649	6,600
Other products*	3,057	5,118	5,000
Total	336,346[r]	357,761[e]	407,600

Source: Dominion Bureau of Statistics.
*Colour, pigments, gypsum products, textiles, medicinals and miscellaneous other 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.

Exports of sodium sulphate, almost all to the United States, increased at an average annual rate of 12 per cent from 1958 to 1967 to reach a record 123,833 tons in 1967. In 1968 exports amounted to 108,984 tons valued at $2.4 million, a tonnage decrease of 12 per cent and a value increase of 10.5 per cent from 1967.

Imports of sodium sulphate, mainly from the United States, have remained fairly steady around 30,000 tons annually during the past 15 years. In 1968 imports totalled 25,018 tons valued at $604,000. Most of Canada's sodium sulphate imports are of the byproduct type which tend to have a higher purity suitable for use in the manufacture of glass and detergents; however it is anticipated that improved product purity of some shipments from Saskatchewan will replace some imports during the course of the next few years. A portion of the imports serve markets in eastern Canada that are not readily accessible by shipments from Saskatchewan.

Although the producers in Saskatchewan are centrally located with respect to major market areas – British Columbia and Ontario and Quebec – freight charges may represent more than one half the cost of sodium sulphate to the consumer.

PRICES

The Canadian price of sodium sulphate (salt cake), bulk, carload, f.o.b. works, as reported by *Canadian Chemical Processing* in October 1968 was $18.00 a ton, an increase of $1.50 from 1967.

According to *Oil, Paint and Drug Reporter* of December 30, 1968, the United States prices of sodium sulphate were:

	(short ton)
Detergent, rayon-grade, carlots, f.o.b. works	
bags	$40.00
bulk	$34.00
Crude (salt cake) 100%, Na_2SO_4, domestic bulk, f.o.b. works	$28.00

TARIFFS

CANADA	
Sodium sulphate, crude or salt cake, per lb	
British Preferential	1/5¢
Most Favoured Nation	1/5¢
General	3/5¢
UNITED STATES	
Crude (salt cake)	free
Anhydrous, per long ton	
Jan. 1, 1968 to Dec. 31, 1968	45¢
Jan. 1, 1969 to Dec. 31, 1969	40¢
Crystallized (Glauber's salt), per long ton	
Jan. 1, 1968 to Dec. 31, 1968	90¢
Jan. 1, 1969 to Dec. 31, 1969	80¢

Reductions under the Kennedy Round of the General Agreement on Tariffs and Trade (Gatt), that was convened in 1964 and concluded in 1967, will lower United States tariffs to 25¢ and 50¢, respectively, on and after Jan. 1, 1972.

Source: Tariff Schedules of United States, Annotated (1969), TC Publication 272.

Stone, Building and Ornamental

F.E. HANES*

Revised figures for the production of building and ornamental stone in Canada for 1966 are 261,573 short tons valued at $12,898,069. Preliminary figures in the 1967 review for the 1966 production should be corrected to conform with these final figures.

Total production in 1966 increased in volume by 60 per cent and in value by 28 per cent approximately, compared with 1965 production.

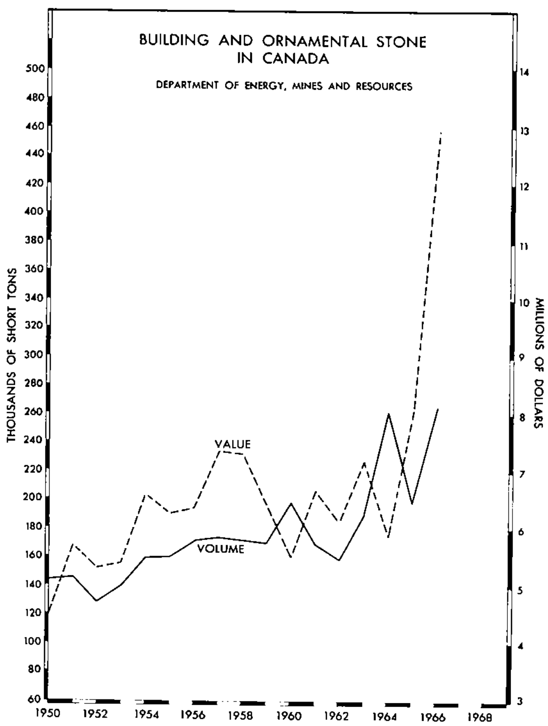
Increased use of building materials in 1966 was due to an increased amount of activity in general construction work with preparations for Expo '67 headlining the activity. Tables 1 and 2 show final statistic values for 1965 and 1966 in detail. Table 3 shows total production only for 1965 and 1966 for both types of production and by area from which produced.

The greatly increased granite production is mainly responsible for the overall high values of production. Quebec is the principal producer of granite with 95 per cent of the total Canadian production of granite to its credit for which it shared 96.5 per cent of the total value realized for granite production in Canada.

Quebec increased its own 1965 production to 142,891 short tons in 1966, an increase of 66 per cent for which it realized an increase of 69 per cent in the value of this product.

No record of sandstone production in Quebec in 1965 was reported, however, in 1966, 4,000 short tons of stone (13 per cent of the Canadian total) was quarried at a low value of $10 per ton.

Quebec almost trebled its limestone production which was valued at over a million and a half dollars ($1.58 million), more than the limestone producers in western Canada in value. Ontario who almost doubled the volume of limestone produced in Quebec, received approximately a third of the amount received by Quebec.



Quebec's share of the total Canadian building and ornamental stone production amounted to 64 per cent in 1966.

*Mineral Processing Division, Mines Branch.

TABLE 1

Production of Building and Ornamental Stone, 1966

	Granite		Limestone		Marble		Sandstone		Total	
	Short Tons	$	Short Tons	$	Short Tons	$	Short Tons	$	Short Tons	$
By type										
Building										
Rough	38,972	794,708	30,234	308,069	2,785	116,685	26,719	518,005	98,710	1,737,467
Dressed	56,675	4,910,290	38,338	2,904,837	130	7,500	1,000	37,400	96,143	7,860,027
Total	95,647	5,704,998	68,572	3,212,906	2,915	124,185	27,719	555,405	194,853	9,597,494
Monumental										
Rough	29,892	1,092,093	2,095	48,532	–	–	–	–	31,987	1,140,625
Dressed	6,522	1,742,966	100	4,000	–	–	3,293	131,746	9,915	1,878,712
Total	36,414	2,835,059	2,195	52,532	–	–	3,293	131,746	41,902	3,019,337
Flagstone	3,950	26,645	6,303	59,264	–	–	340	9,000	10,593	94,909
Curbstone	9,225	176,329	–	–	–	–	–	–	9,225	176,329
Paving	5,000	10,000	–	–	–	–	–	–	5,000	10,000
Total	18,175	212,974	6,303	59,264	–	–	340	9,000	24,818	281,238
Grand total	150,236	8,753,031	77,070	3,324,702	2,915	124,185	31,352	696,151	261,573	12,898,069
By areas										
Atlantic provinces	1,192	148,303	605	2,965	–	–	2,350	79,125	4,147	230,393
Quebec	142,891	8,446,913	20,578	1,585,716	–	–	4,010	42,000	167,479	10,074,629
Ontario	2,647	52,815	39,135	572,079	2,915	124,185	22,782	502,295	67,479	1,251,374
Western provinces	3,506	105,000	16,752	1,163,942	–	–	2,210	72,731	22,468	1,341,673
Total, Canada	150,236	8,753,031	77,070	3,324,702	2,915	124,185	31,352	696,151	261,573	12,898,069

TABLE 2

Production of Building and Ornamental Stone, 1965*

	Granite		Limestone		Marble		Sandstone		Total	
	Short Tons	$	Short Tons	$	Short Tons	$	Short Tons	$	Short Tons	$
By type										
Building										
Rough	20,873	413,160	29,669	343,511	2,404	107,619	21,134	524,873	74,080	1,389,163
Dressed	20,409	2,588,336	33,563	1,258,840	–	–	6,925	296,250	60,897	4,143,426
Total	41,282	3,001,496	63,232	1,602,351	2,404	107,619	28,059	821,123	134,997	5,532,589
Monumental										
Rough	36,259	333,279	10	350	–	–	–	–	36,269	333,629
Dressed	10,739	1,805,298	100	4,000	–	–	–	–	10,839	1,809,298
Total	46,998	2,138,577	110	4,350	–	–	–	–	47,108	2,142,927
Flagstone	926	17,127	4,192	37,577	–	–	8,387	120,321	13,505	175,025
Curbstone	7,520	203,372	–	–	–	–	380	5,320	7,900	208,692
Paving	–	–	100	4,000	–	–	1,124	8,992	1,224	12,992
Total	8,446	220,499	4,292	41,577	–	–	9,891	134,633	22,629	396,709
Grand total	96,726	5,360,572	67,634	1,648,278	2,404	107,619	37,950	955,756	204,714	8,072,225
By areas										
Atlantic provinces	1,226	183,416	491	2,460	–	–	3,675	190,250	5,392	376,126
Quebec	86,019	4,998,244	6,855	284,614	24	240	–	–	92,898	5,283,098
Ontario	1,981	28,912	49,597	761,972	2,380	107,379	31,650	645,290	85,608	1,543,553
Western provinces	7,500	150,000	10,691	599,232	–	–	2,625	120,216	20,816	869,448
Total, Canada	96,726	5,360,572	67,634	1,648,278	2,404	107,619	37,950	955,756	204,714	8,072,225

* Final values.

TABLE 3

Canada – Production of Building and Ornamental Stone 1965 and 1966

	1965		1966	
	Short Tons	$	Short Tons	$
By type				
Granite	96,726	5,360,572	150,236	8,753,031
Limestone	67,634	1,648,278	77,070	3,324,702
Marble	2,404	107,619	2,915	124,185
Sandstone	37,950	955,756	31,352	696,151
Total	204,714	8,072,225	261,573	12,898,069
By areas				
Atlantic provinces	5,392	376,126	4,147	230,393
Quebec	92,898	5,283,098	167,479	10,074,629
Ontario	85,608	1,543,553	67,479	1,251,374
Western provinces	20,816	869,448	22,468	1,341,673
Total	204,714	8,072,225	261,573	12,898,069

Production of building and ornamental stone in Ontario dropped from 85.6 to 67.5 thousands of short tons for a 20 per cent loss of almost $300,000.

Losses in limestone and sandstone production established the downward trend in Ontario for the period from 1965 to 1966. The increase from 1,981 to 2,647 short tons of granite for an increased value of $24,000 was not sufficient to offset Ontario's losses in other stone production.

The Atlantic provinces' production dropped from 5,392 to 4,147 short tons with a loss in value of $146,000. The Atlantic provinces' two principal stone industries are sandstone and granite and in each, values in 1966 decreased from 1965 values from $190,000 to $80,000 for the former, and from $183,400 to $148,000 for the latter.

Losses were also reported in the granite and sandstone industries from the western provinces. Granite production decreased from 7,500 to 3,500 short tons for a 30 per cent loss in value from 1965 to 1966. The sandstone industry decreased its production by approximately 400 short tons for a drop in value of $50,000. However, offsetting these two losses was the increased activity in the limestone industry during 1966. Increases in total stone for this area amounting to 2,350 short tons with an increase from $869,448 in 1965 to $1,341,673 in 1966 resulted from the 6,000 ton increase in limestone at an increased value in 1966 of almost 100 per cent.

By types of stone products produced in Canada, building stone granite led others, increasing from 20.4 to 56.7 thousand short tons for an 88.5 per cent increase in value from 1965 to 1966. Monumental granite products commanded a better dollar per ton value with a substantial $700,000 increase in 1966 over the $2.14 million industry reported in 1965. Granite flagstone production likewise flourished in 1966.

Dressed limestone building stone increased to $2.9 million in 1966 from a $1.26 million value in 1965 for only an increased production of 5,000 tons above the 33,563 tons produced in 1965. A large quantity of rough monumental stone amounting to 2,095 tons was produced from limestone deposits in 1966 for $48,532; this is not comparable with 1965 production which was negligible. An unusual volume of stone production in a usually low-production type classification suggests that some specific ornamental/monumental type of structure was erected during that period. Only a small quantity of limestone is used for individual monumental markers. An increased use of limestone flagstone products was reported in 1966.

Marble production was restricted to Ontario in 1966. Most of the production appeared as building material and sold as rough blocks. A modest increase in production and value was reported in 1966 compared with that for 1965.

Sandstone production lost ground in all categories with one exception; 5.6 thousand tons of rough building stone was quarried. Values for the 1966 stone were lower than in 1965.

Production figures for 1967 and 1968 by types are not available. Table 4, Construction in Canada, indicates an optimistic trend in construction. Residential and institutional construction increases augur well for the stone industry if architects and contractors apply their trades on an aesthetic and quality-conscious level. The use of natural stone of good quality has been synonymous with the desire to build for durability and prestige. On this premise we might

TABLE 4

Construction in Canada
1966 – 1967 – 1968 – 1969
(millions of dollars)

	1966	1967	1968	1969
Total construction	11,237	11,594	12,242	13,266
Total building	6,661	6,826	7,283	8,022
Residential	2,843	3,065	3,573	3,973
Industrial	1,001	870	731	784
Commercial	1,250	1,221	1,156	1,301
Institutional	1,170	1,258	1,397	1,504
Other building	397	412	426	460
Total engineering	4,576	4,768	4,959	5,244

interpret the values shown in Table 4 with an optimistic outlook for the future of the stone industry. However, it is unlikely that as high a rate of increase in production can continue at the rate established during the peak years of 1966-1967.

IMPORTS AND EXPORTS

Imports and exports for 1967 are shown in Table 5 along with preliminary estimates of values for 1968. The table has some items which were not included in previous years. To be correlative, these categories are removed from Table 5. The total amount of imports without the crushed product would be $3,234,000 for 1967, a final value, and $2,568,000 for 1968, a preliminary value. Imports for 1965 and 1966 were $3,183,217 and $2,983,000 respectively.

An increased volume of material was imported in 1967 comparing the value of similar products in 1965 and 1966. Preliminary values in 1968 are low and

TABLE 5

Imports and Exports

	1967		1968P	
	Short Tons	$	Short Tons	$
Exports				
Building stone, rough	22,344	784,000	18,552	777,000
Stone crude, n.e.s.*	78,250*	287,000*	252,596*	264,000*
Natural stone basic products	100,594	2,138,000	271,148	2,669,000
Total		3,209,000*		3,710,000*
		2,922,000		3,446,000
Imports				
Stone, crushed, incl. refuse*	1,306,144*	3,473,000*	1,379,580*	3,266,000*
Stone crude, n.e.s.	2,908	90,000	19,276	92,000
Building stone rough, n.e.s.	11,659	409,000	12,919	442,000
Granite, rough	12,312	568,000	13,166	582,000
Marble, rough	7,643	671,000	5,745	495,000
Shaped or dressed granite	..	290,000	..	227,000
Shaped or dressed marble	..	870,000	..	483,000
Natural stone basic products	..	336,000	..	247,000
Total		6,707,000*		5,834,000*
		3,234,000		2,568,000

* Items not included in previous tables.
P Preliminary.

would indicate a trend toward industry's capacity to provide more of our own stone demands.

Export values indicate an increased volume of stone was sent out in 1967 and 1968 (preliminary) compared with the 1965 and 1966 figures. Increases of $500,000 in value of stone exported in 1968 compared with 1967 and tripled with the 1965 value assists our own stone development by increased participation in foreign markets which are highly competitive and quality-demanding.

PRICES

Table 6 shows average values for the production of all types of stone in various categories. Such values can be significant if a comparison can be made from year to year. Reference to volume figures shown in Tables 1 and 2 should be made while considering average price values.

An example of the above is cited; the volume of rough granite monumental stone produced in 1966 was a decrease of 18 per cent over the 1965 product. The value of the smaller production increased 228 per cent which raised the average value per ton from $9.19 in 1965 to $36.53 in 1966.

A decrease of 39 per cent in volume of dressed monumental stone accompanied by little difference in its value resulted in an average price differential of $168.11 to $267.24 per short ton. Since Quebec produced 95 per cent of the granite, these anomalies in average prices tell a history of production, marketing, quality variation and the disposition of the industry for the period. The total Quebec granite production varied only by $1.00 between 1965 and 1966.

Information showing the production of limestone in Quebec and the western provinces and their respective values reveals the trend in their respective provinces.

Average prices were lower for the marble production which was restricted to Ontario in 1966, however, the industry is little changed.

A large decrease in the dressed building stone industry was reflected through average price per ton values. The Atlantic and western province areas are both responsible for a considerable production of lower valued material. Ontario dropped in volume but produced a higher quality material to increase the value of its sandstone production in 1966.

Total stone production for the western provinces and Quebec raised average prices per ton of material considerably in 1966 over the 1965 price. Both increased their production, particularly Quebec, which was referred to earlier in the discussion on granite production. Ontario's average price remained static but with accompanying lower volume and value products. The maritime provinces with lower production and decreased value dropped sharply in value per ton of its production.

Total Canadian production with both volume and value increases showed a strong 25 per cent increase in average price per short ton from $39.43 in 1965 to $49.31 in 1966.

CANADIAN DEPOSITS OF BUILDING AND ORNAMENTAL STONE

Potentially producible stone deposits are considered in the following list of available stone materials in Canada. Some quarries are operated sporadically, operating only in the more suitable months of the year. During these few months, all the rock required by the company is blocked out and usually transported to dressing plants or stockpiled at the quarry site. Much depends on the location of the quarry and its access to suitable transportation facilities.

The following types of stone were available from the following areas during 1968.

GRANITE

Nova Scotia. Grey granite is produced from Middleton-Nictaux and Shelburne and black diorite is quarried in the Shelburne area. Quartzitic rock referred to as 'blue stone' is produced from the Echo Lake area northeast of Dartmouth with some of the same stone potentially available from the Ostrea Lake area. A grey, coarse-grained granite and an 'iron-stone' are available in the Halifax area. Grey granite boulders are recovered from the Queensport area. A deposit of grey-speckled, black diorite is being quarried near West Erinville.

New Brunswick. A coarse- to medium-grained, grey-brown granite is sporadically quarried near St. Stephen, and fine- to medium-grained, grey, pink and blue-grey granites are quarried in the Hampstead (Spoon Island) district. A brown, pink-grey, coarse-grained granite is quarried sporadically near Bathurst. A deposit of light pink to salmon coloured, medium-grained granite is quarried in the Antinouri Lake district. A black ferromagnesian rock containing plagioclase feldspar, augite, pyroxene, and hornblende is quarried in the Bocabec River area. Some of the red, St. George granite deposits are potential producers of building stone but are currently not being utilized.

Quebec. Numerous quarries south of the St. Lawrence River supply fine- to medium-grained, grey and grey-white granites. These quarries are in the vicinities of Stanstead, St-Samuel–St-Sebastien and St-Gerard. Grey granite is also available from the Scotstown area. Dark grey-blue granites are quarried from the Monteregiàn hills.

North of the St. Lawrence River, red, brown, green and black granites are quarried in the Lake St. John-Roberval-Chicoutimi area; anorthositic black rocks and a fine-grained pink-red granite are quarried north of Alma on the banks of the Peribonka River

TABLE 6

Average Prices of Stone by Type and Area*
(revised)

	Granite		Limestone		Marble		Sandstone		Total	
	1965	1966	1965	1966	1965	1966	1965	1966	1965	1966
By type										
Building										
Rough	19.79	40.18	11.58	10.19	44.76	41.90	24.84	19.39	18.75	17.60
Dressed	126.80	86.64	37.51	75.77	–	57.69	42.78	37.40	68.04	81.75
Ornamental										
Rough	9.19	36.53	35.00	23.17	–	–	–	–	9.20	35.66
Dressed	168.11	267.24	40.00	40.00	–	–	–	40.01	166.93	189.44
Flagstone	18.50	6.75	8.96	9.40	–	–	14.35	26.47	12.96	8.96
Curbstone	27.04	19.11	–	–	–	–	14.00	–	26.42	19.11
Paving	–	2.00	40.00	–	–	–	8.00	–	10.61	2.00
By area										
Atlantic provinces	149.60	124.42	5.01	4.00	–	–	51.77	33.67	69.76	55.56
Quebec	58.11	59.11	41.52	77.06	10.00	–	–	10.47	56.87	60.15
Ontario	14.59	19.95	15.36	14.62	45.12	42.60	20.39	22.05	18.03	18.54
Western provinces	20.00	29.95	56.05	69.48	–	–	45.80	32.91	41.77	59.71
Total	55.42	58.26	24.37	43.14	44.76	42.60	25.18	22.20	39.43	49.31

* Dollars per short ton.
– No production reported.

and from the St-Ludger-de-Milot area. Medium- to coarse-grained blue-grey, rose-grey, deeper pink-grey, dark green and brown coarse-grained granites are quarried in the Rivière-à-Pierre area. Black and grey and pink-grey gneissic rocks are quarried in the Rivière-à-Pierre area. Black and grey and pink-grey gneissic rocks are quarried in the Rivière-à-Pierre and Notre-Dame-des-Anges areas. A red-pink granite comes from St-Alban and a banded, pink-red gneiss comes from St-Raymond. Fine-grained, pink-coloured granite comes from the Laurier-Guenette area and a grey-pink gneiss is quarried at L'Annonciation. An augen-type granite is produced near Mont-Tremblant and a coarse-grained, brown granite is quarried in the St. Alexis-des-Monts area. Grey-speckled, black gabbroic rock is quarried in the Montpellier area and a dark-coloured anorthositic rock is quarried in the Rouyn area. Brown-red to green-brown syenites are quarried in the Grenville district while a mauve-red granite is produced in the Ville Marie area on Lake Timiskaming.

Ontario. A salmon-pink, medium-grained granite is potentially available near Kenora at Vermilion Bay. A black anorthosite is available from the River Valley area north of Sturgeon Falls near North Bay. Rough building blocks are quarried near Parry Sound from a multicoloured gneissic rock. Potential production of red granite is available in the Lyndhurst and Gananoque areas. Deposits of black and red granite along the north shore of Lake Superior are potential sources of dimension stone while a large massive red granite rock is produced north of Havelock.

Manitoba. A durable, red granite of good quality is being quarried in the Lac du Bonnet area, 70 miles northeast of Winnipeg. Deposits of grey granite east of Winnipeg near the Ontario border are potential suppliers of building stone for local use.

British Columbia. A light-grey and blue-grey, even-grained granite is potentially available from both Nelson Island and Granite Island. Also potentially available is an andesite that has been used in building construction in Victoria and Vancouver in the past.

LIMESTONE

New Brunswick. Limestone for building construction is produced in the Saint John area.

Quebec. A fine- to medium-grained, fossiliferous, brownish grey limestone is available in the vicinity of St-Marc-des-Carrieres. Rough building stones are produced in small quantities from quarries located in the Montreal area. Variable amounts of building blocks are quarried at scattered points in the province for local use.

Ontario. Much of Ontario's production comes from deposits of a dense, hard, grey-blue limestone in the Niagara Falls area. A thin-bedded, dense, buff to buff-grey limestone is quarried on the Bruce Peninsula near Wiarton and Owen Sound, and some dark grey limestone is quarried near Ottawa. Potential building material is available from very fine-grained deposits in the Manitoulin Island area.

Manitoba. A mottled, buff-brown to grey-brown dolomitic limestone, known as 'Tyndall' limestone, is quarried in the Garson area. It is effectively used in rough and sawn finishes and can take a polish for use as a decorative stone. Other smaller deposits of stone are produced for local use.

SANDSTONE

Nova Scotia. A massive-textured, fine- to medium-grained, olive-buff stone is quarried in the Wallace area. Small deposits are quarried for local use in several areas.

New Brunswick. A red, fine- to medium-grained sandstone is quarried from a deposit in Sackville; this stone is restricted in its use for construction of buildings on the Mount Allison University campus at Sackville. Numerous local-use deposits are situated about the province. The Miramichi quarry at Quarryville is currently not being worked.

Quebec. A deposit of buff and red sandstone is potentially available in the Trois-Pistoles area. Several small deposits are being quarried for rough-face blocks of sandstone for local use. Sandstones are potentially available in the Quebec-Levis area from the Sillery formation.

Ontario. From thin-bedded sandstone deposits, numerous quarries along the scarp face of the Caledon Hills, between Georgetown and Orangeville, produce a fine-grained, sometimes mottled or speckled building stone that is varicoloured in light buff, brown and deep brown-red. Medium-grained, buff- to cream-coloured stone near Bells Corners is in limited supply. A highly coloured, medium-grained, banded and mottled sandstone is available from deposits located approximately 20 miles north of Kingston. There are other small deposits scattered throughout the province that are being exploited for local use.

Alberta. A hard, very fine-grained, medium-grey sandstone, sometimes referred to as 'Rundle stone', is quarried near Banff. It is used as rough building stone. Potential deposits of a buff-brown sandstone are located in the province.

MARBLE

Quebec. A small quantity of light and dark grey, green-white mottled marble is available for production in the Philipsburgh area and Stukely area. These deposits are not being worked at the present time.

Ontario. Blue, blue-white, buff, pink, white and grey recrystallized limestone marbles are available in an area extending from Perth to Almonte. Also available from this area is a serpentinized marble. Potential sources of marble are being investigated as far west as Peterborough and as far north as Bancroft, Rock from a deposit of limestone from the Wiarton area is amenable to a high-polish and may find some market as a marble product.

Sulphur

P.R. COTE*

Sulphur, a commodity that had been in short supply from 1963 to early 1968, reached a balanced supply-demand situation by mid-1968. The balance was brought about by increased production of elemental sulphur, particularly in Canada and Poland, and by weakened demands for fertilizer manufacture, which consumes approximately 50 per cent of the world's sulphur output. In 1968, production of sulphur in all forms in the western world increased by 6.5 per cent to 27.7 million metric tons and world consumption increased about 3.5 per cent. The rate of increase in consumption was lower than the historical trend of about 4 to 5 per cent annually and considerably lower than the 8 per cent average annual increase experienced from 1963 to 1966. The increased production and slackening demands converted a deficit of about 600,000 tons** in 1967 to a surplus of some 1.0 million tons at the end of 1968.

Since 1960, Canada has changed from a net importer of sulphur to become, in 1968, the world's largest exporter of elemental sulphur and the western world's second largest producer, surpassed only by the United States. Canada has supplied about one third of the world's additional output of elemental sulphur since the early 1960's. Domestic annual year-end capacity of sulphur from sour natural gas stood at 3.75 million tons, a 22 per cent increase from 1967.

Sulphur is one of mankind's most important industrial chemicals and has a wide variety of uses. It is produced in one form or another in some 60 countries. Almost one half of the world's output is produced in the elemental form from native sulphur deposits and from sour natural gas. An equal amount is recovered from metallic sulphides with minor quantities from sulphates. Nearly all sulphur is consumed in the form of sulphuric acid of which one half is used in the manufacture of fertilizers. The chemicals, and pulp and paper industries are the next largest consumers.

PRODUCTION AND DEVELOPMENTS IN CANADA

Canadian sulphur shipments in 1968 amounted to 3.3 million tons valued at $90.4 million representing a tonnage increase of 1.1 per cent and a value increase of 16.7 per cent from 1967. Canadian sulphur production falls into three statistical classes: elemental, smelter, and pyrite and pyrrhotite concentrates. Approximately 78 per cent of Canada's sulphur output in 1968 was in elemental form. Most of the latter was recovered from hydrocarbon sources for which sour natural gas in western Canada was by far the most important. Elemental sulphur was also recovered from crude oils at some oil refineries, the Athabasca oil sands, and minor quantities from the electrolytic refining of nickel-sulphide matte. As indicated by the statistical classification, the remainder of Canada's sulphur output came from metallic sulphides either in pyrites shipped or in smelter gases.

In 1968 development and production activity was again directed toward hydrocarbon and metallic sulphide sources. Some interest focussed on sedimentary occurrences of native sulphur in northern Alberta.

*Mineral Resources Branch.

**Short tons of 2,000 lbs used throughout unless otherwise noted.

TABLE 1

Canada, Sulphur Production and Trade, 1967-68

	1967		1968p	
	Short Tons	$	Short Tons	$
Production (shipments)				
Pyrite and pyrrhotite[1]				
Gross weight	377,941		320,090	
Sulphur content	182,377	1,702,516	159,036	2,215,161
Sulphur in smelter gases[2]	592,035	7,182,139	565,696	6,951,687
Elemental sulphur[3]	2,499,205	68,613,866	2,585,513	81,276,703
Total sulphur content	3,273,617	77,498,521	3,310,245	90,443,551
Imports				
Sulphur, crude or refined				
United States	124,761	4,343,000	75,815	3,057,000
France	20	3,000	–	–
Total	124,781	4,346,000	75,815	3,057,000
Exports				
Sulphur in ores (pyrite)				
United States	. .	952,000	. .	930,000
Taiwan	. .	115,000	. .	126,000
Total		1,067,000		1,056,000
Sulphur, crude or refined, n.e.s.				
United States	826,914	19,051,000	919,654	27,789,000
Australia	237,209	9,104,000	323,724	12,453,000
India	263,732	12,633,000	245,414	10,537,000
Republic of South Africa	60,239	2,319,000	131,228	4,971,000
New Zealand	65,957	2,386,000	114,622	4,056,000
South Korea	61,444	2,420,000	114,577	5,301,000
Taiwan	63,045	3,367,000	83,962	3,682,000
Hungary	35,894	1,001,000	44,702	1,895,000
Brazil	–	–	33,314	1,357,000
Greece	27,231	1,026,000	15,945	676,000
Italy	16,665	778,000	14,327	619,000
Other countries	115,341	4,614,000	69,666	3,090,000
Total	1,773,671	58,699,000	2,111,135	76,426,000

Source: Dominion Bureau of Statistics.
[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; n.e.s. Not elsewhere specified.

HYDROCARBON SOURCES

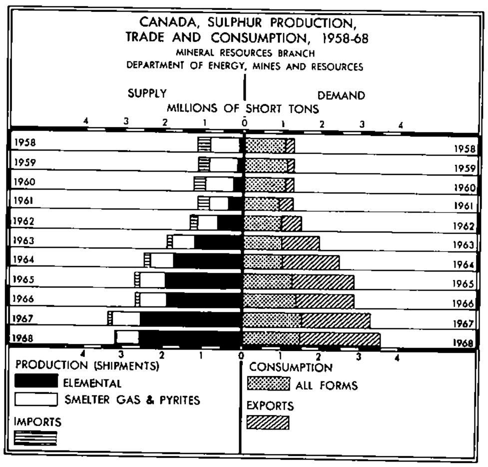
Most hydrocarbons contain sulphur. Minute sulphur contamination seldom presents a serious problem in marketing and utilization of hydrocarbons but when the sulphur content is unacceptably high it must be lowered. Sulphur present in natural gases is normally in the form of hydrogen sulphide (H_2S), a highly corrosive and noxious gas. Hydrogen sulphide is also a common constituent of sulphurous crude oils and coal. Sulphur recovered from hydrocarbons constitutes about one fifth of total world production.

Canada is the world's largest producer of sulphur from hydrocarbon sources, a remarkable achievement considering that prior to 1951, there was no Canadian production of sulphur from sour natural gas. Since 1960, elemental sulphur production in Canada has increased over ten-fold.

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.

Raw sour gas is passed through a solution, normally monoethanolamine, which has an affinity for hydrogen sulphide. Concentrated H_2S is distilled off and passed into a Claus furnace where it is burned in a controlled air flow to form a mist of elemental sulphur droplets. The mist is condensed to molten sulphur and pumped to storage.



Canada's first sour gas sulphur plant came on stream in Alberta in 1951. By the end of 1968, 26 recovery plants were operating in Alberta and one each in British Columbia and Saskatchewan. Cumulative production to the end of 1968 in Alberta, as reported by the Oil and Gas Conservation Board, was 10,240,000 long tons of elemental sulphur. About 1,385,000 long tons of sulphur were in stockpiles at the end of the year an increase of some 770,000 long tons over 1967. According to the Board, Alberta's recoverable reserves of sulphur from sour gas fields amount to an estimated 139.7 million long tons. Combined daily capacity of the sour gas plants in the three provinces was 12,420 long tons at the end of 1968. This daily capacity, which is based upon the designed maximum raw gas throughput, is never sustained throughout the year as gas sales are subject to seasonal fluctuations. If one makes an allowance for these fluctuations in gas processing, an annual operating rate of about 3.75 million short tons becomes realistic.

In 1968, production of elemental sulphur in Alberta, as reported by the Oil and Gas Conservation Board, was 2,989,588 long tons, an increase of 41 per cent from 1967. Shipments of elemental sulphur in Canada in 1968 totalled 2,585,513 tons, representing an increase of 3.5 per cent over 1967. Value of shipments was $81,276,703, up 18.5 per cent.

Five sour gas plants, with a combined daily rated capacity of 2,932 long tons of sulphur, came on stream in Alberta in 1968. They were: Pan American Petroleum Corporation, East Crossfield (1,480 long tons a day) and Bigstone (320); Banff Oil Ltd., Rainbow Lake (70); Hudson's Bay Oil and Gas Company Limited, Caroline (18); and Kaybob South (1,044). The additional capacity represents a 31 percent increase over that at the end of 1967 and could boost Canada's elemental sulphur production by about 900,000 short tons annually. This spectacular growth rate is likely to continue into 1969 and 1970. New plants and expansions scheduled for completion in 1969 and early 1970 should add a further 5,656 long tons to daily rated capacity, a 45 per cent increase over capacity at the 1968 year-end. Capital expenditures on these proposed plants and expansions will be in the order of $95 million.

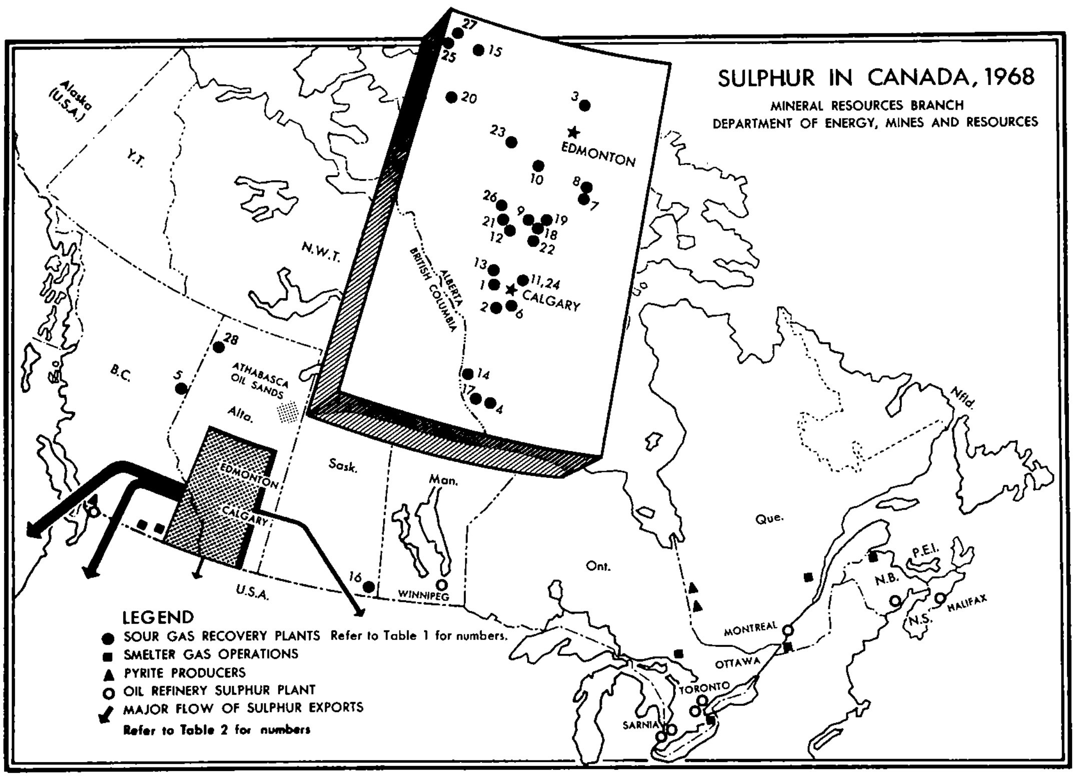
Athabasca Oil Sands

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 Oil and Gas Conservation Board of Alberta estimated 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.

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 approved scheme allows GCOS to produce 45,000 barrels of synthetic crude daily. The sulphur plant is designed to produce 300 long tons of sulphur daily. Considerable difficulty was experienced in start up operations and sulphur recovery has not reached the designed rate.

Oil Refineries

Some crude oils contain as much as 5 per cent sulphur either as hydrogen sulphide or in some other compound. Domestic crudes generally contain less that 1 per cent sulphur. The sulphur may either be removed in the form of H_2S or treated to form non-deleterious 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 (estimated at 60,000 tons in 1968) is not included in Canadian sulphur production statistics. Sulphur, recovered from domestic crudes at oil refineries near Toronto, Sarnia, and Winnipeg amounted to an estimated 40,000 tons in 1968.

In 1968, Shell Canada Limited began recovering sulphur at its oil refinery near Vancouver, British Columbia; the refinery uses domestic crude and the sulphur recovery unit has a capacity of 16 long tons a day.

Coking Operations

Coke oven gases generally contain some hydrogen sulphide, the quantity being 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.

Beginning in mid-1967, Dominion Foundries and Steel, Limited, at Hamilton, Ontario, began producing elemental sulphur from coke oven gas using the British-developed Stretford Process. Capacity of the plant allows for the recovery of 8 tons of sulphur daily.

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 of Canada's sulphur production came from metallic sulphides prior to 1951 at which time the first sour gas plant was built. In 1968, metallic sulphides provided almost 725,000 tons of contained sulphur and accounted for 22 per cent of Canada's total sulphur production.

Smelter Gases

The recovery of sulphur from smelter gases is accomplished in the following manner. Effluent gas, normally containing from 1 to 12 per cent sulphur dioxide, is cleaned and the SO_2 is purified and cooled. Concentrated SO_2 is then used directly for the manufacture of H_2SO_4 via the contact-acid process.

TABLE 2
Principal Sulphur Plants and Operations in Canada, 1968

Operating Company	Source Field or Plant Location	% H_2S or Raw Material	Daily Capacity Long Tons	Annual Recovery Short Tons	Principal Product
SOUR GAS PLANTS					
	(numbered on Map)		(Rated)*	(Estimated)	
1. Shell Canada**	Jumping Pound, Alta.	3-5	240	75,000	S
2. Royalite Oil	Turner Valley, Alta.	4	35	7,000	S
3. Imperial Oil	Redwater, Alta.	3	13	2,500	S
4. Gulf Oil Canada	Pincher Creek, Alta.	10	675	85,000	S
5. Jefferson Lake Petro.	Taylor Flats, B.C.	3	325	60,000	S
6. Texas Gulf Sulphur	Okotoks, Alta.	33	370	160,000	S
7. Gulf Oil Canada	Nevis, Alta.	3-7	123	35,000	S
8. Chevron Standard	Nevis, Alta.	7	140	48,000	S
9. Shell Canada	Innisfail, Alta.	14	100	25,000	S
10. Gulf Oil Canada	Rimbey, Alta.	1-3	326	105,000	S
11. Petrogas Processing	Crossfield, Alta.	31	1,940	630,000	S
12. Home Oil	Carstairs, Alta.	1	48	11,000	S
13. Canadian Fina Oil	Wildcat Hills, Alta.	4	137	45,000	S
14. Jefferson Lake Petro.	Savannah Creek, Alta.	13	375	34,000	S
15. Texas Gulf Sulphur	Windfall, Alta.	16	1,350	450,000	S
16. Steelman Gas	Steelman, Sask.	1	12	2,000	S
17. Shell Canada	Waterton, Alta.	18-25	1,650	500,000	S
18. Amerada Petroleum	Olds, Alta.	11	180	68,000	S
19. Mobil Oil Canada	Wimborne, Alta.	14	295	90,000	S
20. Hudson's Bay Oil and Gas	Edson, Alta.	3	229	44,000	S
21. Canadian Superior Oil	Harmattan-Elkton, Alta.	53	805	290,000	S
22. Hudson's Bay Oil and Gas	Lone Pine Creek, Alta.	8-17	102	28,000	S
23. Canadian Delhi Oil	Minnehik-Buck Lake, Alta.		18	5,500	S
24. Pan American**	East Crossfield, Alta.	34	1,480	430,000	S
25. Pan American**	Bigstone, Alta.	19	320	95,000	S
26. Hudson's Bay Oil and Gas**	Caroline, Alta.		18	5,000	S
27. Hudson's Bay Oil and Gas**	Kaybob South, Alta.	2-17	1,044	300,000	S
28. Banff Oil**	Rainbow Lake, Alta.		70	20,000	S
	Totals December 31, 1968		12,420	3,750,000	
SULPHIDE SOURCES					
Smelter Gases					
1. Belledune Acid	Belledune, N.B.	SO_2, lead-zinc		40,000	H_2SO_4
2. Alcan	Arvida, Que.	SO_2, zinc conc.		25,000	H_2SO_4
3. Allied Chemical	Valleyfield, Que.	SO_2, zinc conc.		25,000	H_2SO_4
4. Can. Electrolytic Zinc	Valleyfield, Que.	SO_2, zinc conc.		20,000	H_2SO_4
5. Sherbrooke Metallurgical	Port Maitland, Ont.	SO_2, zinc conc.		30,000	H_2SO_4
6. Canadian Industries	Copper Cliff, Ont.	SO_2, pyrrhotite		290,000	H_2SO_4
7. Cominco	Kimberley, B.C.	SO_2, pyrrhotite		110,000	H_2SO_4
8. Cominco	Trail, B.C.	SO_2, lead-zinc		175,000	H_2SO_4
Total contained sulphur in smelter gases				715,000	
Pyrite and Pyrrhotite					
1. Noranda Mines	Noranda, Que.	sulphide ore			pyrite conc.
2. Normetal Mines	Normetal, Que.	sulphide ore			pyrite conc.
3. Quemont Mines	Noranda, Que.	sulphide ore			pyrite conc.
4. Anaconda Company (Canada)	Britannia B., B.C.	sulphide ore			pyrite conc.

* Sour gas plants: daily rated capacities in long tons of 2,240 pounds as reported by respective operators; yearly estimates in short tons are based on past performances; ** Sour gas plants that came on stream in 1968.

Occasionally, the SO_2 gas 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. Production in 1967 was 565,696 tons of contained sulphur representing 17 per cent of Canada's total sulphur output.

An important smelter gas sulphuric acid plant in Canada is Belledune Acid Limited's works at Belledune, New Brunswick; a subsidiary of Brunswick Mining and Smelting Corporation Limited. This company supplies acid to the nearby plant of Belledune Fertilizer Limited, which is also a subsidiary of Brunswick. Canadian Industries Limited (CIL) operates three acid plants at Copper Cliff, Ontario. The plants having a combined daily capacity of 2,255 tons of H_2SO_4. Feed SO_2 gas is from The International Nickel Company of Canada, Limited's iron ore recovery plant. In addition, at the nearby Copper Cliff nickel smelter CIL operates a liquid sulphur dioxide plant. Much of the acid produced at Copper Cliff is shipped by unit train about 475 miles to CIL's fertilizer works near Sarnia, Ontario. 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 285,000 tons of H_2SO_4 a year. Much of the acid produced is utilized by Cominco in the manufacture of fertilizers.

Alcan Aluminium Limited, Allied Chemical Canada, Ltd., Canadian Electrolytic Zinc Limited and Sherbrooke Metallurgical Company Limited produce sulphuric acid from the roasting of zinc concentrates at Arvida and Valleyfield, Quebec and Port Maitland, Ontario.

Pyrite and Pyrrhotite

Pyrite and pyrrhotite concentrates produced as a byproduct from 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.

Four companies are engaged in producing and shipping pyrite and pyrrhotite concentrates (Table 2). Other companies are stockpiling concentrates pending future use. In 1968, Canada's pyrite and pyrrhotite shipments amounted to 320,090 tons of concentrates containing 159,036 tons of combined sulphur valued at $2.2 million; nearly all was exported.

Superior Acid & Iron Limited, a Canadian company incorporated on July 4, 1968, plans to mine pyrite for the manufacture of sulphuric acid and iron ore pellets. The plan calls for the mining and concentration of pyrite from deposits located near Goudreau, Ontario, some 180 miles north of Sault Ste. Marie. The pyrite concentrate would then be shipped to Ashtabula, Ohio, for treatment to yield iron ore pellets and sulphuric acid. Anticipated yield from the planned 2,000 tons a day mill at the minesite would be 400,000 tons of H_2SO_4 and 185,000 tons of iron ore pellets.

Others

Minor tonnages of elemental sulphur are recovered during the electrolytic refining of nickel sulphide matte at Inco refineries at Port Colborne, Ontario, and Thompson, Manitoba.

Elemental sulphur will be produced from iron sulphides by Allied Chemical of Canada, Ltd., at Falconbridge, Ontario, some 20 miles east of Sudbury. Sulphur dioxide gases will be supplied from Falconbridge Nickel Mines, Limited's iron ore recovery plant. Both plants are scheduled to be completed in 1969.

SEDIMENTARY SOURCES

Native sulphur deposits such as those associated with salt dome structures in the Gulf Coast region of the United States and Mexico, and bedded deposits in Poland, USSR and Sicily account for about one third of the world's sulphur production. Although numerous occurrences of native sulphur are known in Canada, none of them have been worked.

Considerable attention was focussed on native sulphur occurrences in northern Alberta and Saskatchewan in 1967 and early 1968, but interest waned somewhat when world sulphur shortages were overcome. Some attention has also been given to the extraction of sulphur from gypsum and anhydrite deposits.

CANADIAN CONSUMPTION AND TRADE

Canadian consumption of sulphur in all forms in 1968 amounted to an estimated 1,490,000 tons of which elemental sulphur accounted for approximately 60 per cent with the remaining 40 per cent being supplied from metallic sulphides.

Production of sulphuric acid in Canada totalled 2,852,000 tons, up 3.7 per cent from 1967. In 1968, sulphuric acid was produced at 19 plants across Canada in all provinces except Saskatchewan Newfoundland and Prince Edward Island.

TABLE 3

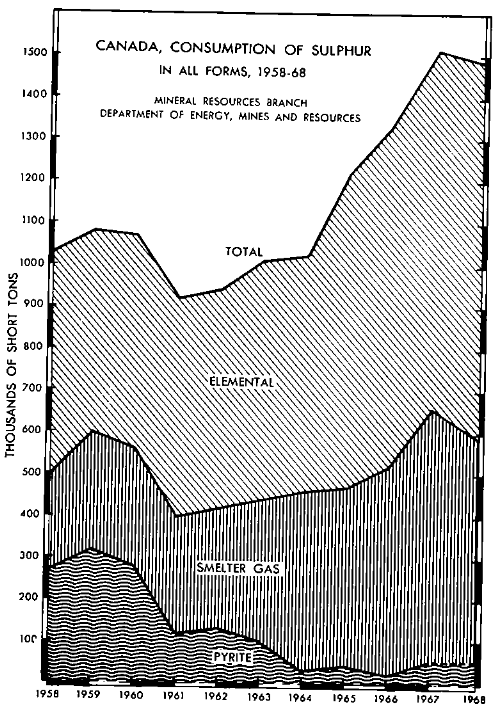
Canada, Sulphur Production and Trade, 1959-68
(short tons)

	Production[1]				Imports	Exports	
	In Pyrites[3]	In Smelter Gases	Elemental Sulphur	Total	Elemental Sulphur	Pyrite[2] $	Elemental Sulphur
1959	465,611	277,030	145,656	888,297	332,430	1,018,608	26,526
1960	437,790	289,620	274,359	1,001,769	328,765	1,259,151	143,040
1961	255,376	277,056	394,762	927,194	329,556	889,755	217,866
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[p]	159,036	565,696	2,585,513	3,310,245	75,815	1,056,000	2,111,135

Source: Dominion Bureau of Statistics.

[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.



Difficulties in handling coupled with transportation costs result in very minor international trade in sulphuric acid. The fertilizer industry, much of which is statistically classified with industrial chemicals, is by far the largest consumer of sulphuric acid.

In 1968, Canada's exports of elemental sulphur reached a record 2,111,135 tons valued at $76.4 million, a tonnage increase of 19 per cent from 1967.

TABLE 4

Canada, Sulphur Consumption, 1959-68
(short tons)

	From Pyrites and Smelter Gases[e]	Elemental Sulphur*	Total[e]
1959	606,518	483,482	1,090,000
1960	552,190	507,810	1,060,000
1961	406,952	513,048	920,000
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	1,330,000
1967	666,627	843,373	1,510,000
1968	590,000	900,000[e]	1,490,000

Source: Dominion Bureau of Statistics.

[e]Estimated. *As reported by consumers.

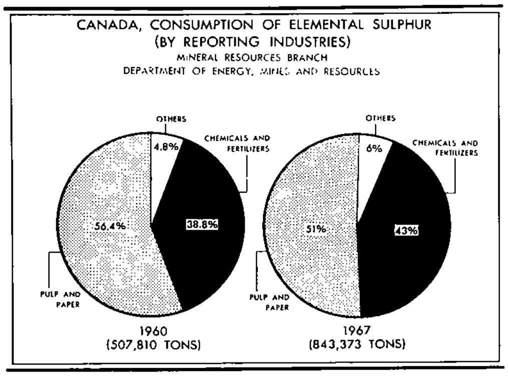
TABLE 5

Canada, Consumption of Elemental Sulphur by Industry, 1966-67
(short tons)

	1966	1967
Chemicals	192,135	187,180
Pulp and paper	463,086	432,482
Rubber products	3,362	3,306
Fertilizers	116,643	185,389
Foundry	14,433	12,962
Other industries*	23,452	22,054
Total	813,111	843,373

Source: Dominion Bureau of Statistics.

*Includes production of titanium pigments, pharmaceuticals, and medicinals, starch, soaps and detergents, explosives, food processing, sugar refining and other minor uses.



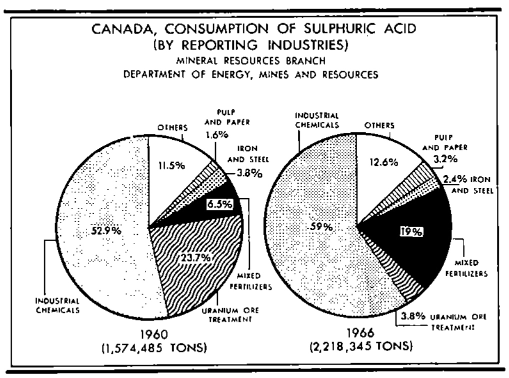


TABLE 6

Canada, Sulphuric Acid Production, Trade and Apparent Consumption, 1959-68
(short tons – 100% acid)

	Production	Imports	Exports	Apparent Consumption
1959	1,739,000	18,489	27,863	1,729,626
1960	1,673,000	9,526	43,430	1,639,096
1961	1,614,000	7,275	38,914	1,582,361
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	2,749,000	3,626	84,280	2,668,436
1968p	2,852,000	2,606	125,971	2,728,635

Source: Dominion Bureau of Statistics.
p Preliminary.

TABLE 7

Canada, Available Data on Consumption of Sulphuric Acid by Industry, 1966
(short tons – 100% acid)

Iron and steel mills	54,163
Other iron and steel	17,907
Electrical products	6,464
Vegetable-oil mills	263
Sugar refineries	257
Leather tanneries	2,178
Textile dyeing and finishing plants	56
Pulp and paper mills	71,218
Processing of uranium ore	84,491
Manufacture of mixed fertilizers[1]	432,057
Manufacture of plastics and synthetic resins	26,132
Manufacture of soaps and cleaning compounds	18,789
Other chemical industries	17,424
Manufacture of industrial chemicals[2]	1,309,870
Petroleum refining	25,932
Mining[3]	47,549
Miscellaneous[4]	103,595
Total accounted for	2,218,345

Source: Dominion Bureau of Statistics.
[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, non-metal mines, mineral fuels and structural materials. [4] Includes synthetic textiles, explosives and ammunition, and other petroleum and coal products.

About 44 per cent of Canada's elemental sulphur exports went to the United States. The average value of Canada's elemental sulphur exports in 1968 was $31.43 a ton compared to $33.09 in 1967 and $24.00 in 1966. Exports of pyrites for the manufacture of sulphuric acid were valued at $1,056,000 in 1968. Exports of sulphuric acid also rose to 125,971 tons, a 50 per cent increase from 1967.

As shown in Table 3, Canada's imports of elemental sulphur have declined sharply over the past 10 years. In 1968, imports amounted to 75,815 tons of elemental sulphur, a decrease of 39 per cent from 1967. Sulphuric acid imports were negligible.

WORLD REVIEW

In 1968, world production of sulphur in all forms reached an estimated 34.5 million metric tons an increase of 5 per cent over 1967. By far the largest increases resulted from developments in western Canada and Poland. Canadian output from sour natural gas in Alberta increased over 40 per cent from the 1967 level while Polish sulphur production increased from about 800,000 metric tons in 1967 to an estimated 1.3 million metric tons in 1968.

The world's largest producer of sulphur in all forms is the United States with the majority of sulphur being derived from Frasch mines located in the Gulf Coast area. These deposits, largely associated with salt dome structures, when developed in the early 1900's, made available to world markets large tonnages of low cost sulphur and as a result, significantly changed the pattern of world sulphur trade. In 1968, Frasch sulphur production in the United States reached 7.5 million long tons, up from 7.0 million long tons in 1967. Easing of the sulphur shortage situation early in 1968 has resulted in a substantial rise in inventories. Producer's stocks of Frasch sulphur stood at 2.7 million long tons at the close of 1968. During the year, Frasch producers reduced the level of operations at a number of mines, which until mid-year had operated at capacity to satisfy consumer demands. In April, Freeport Sulphur Company temporarily closed down its recently opened Caminada offshore dome. Elcor Corporation had planned to extract sulphur from gypsum deposits in West Texas at a rate of 350,000 tons a year beginning early in 1968. However,

TABLE 8

World Production of Sulphur in All Forms 1967-68
('000 metric tons)

	1967					1968^e
	Frasch	Other Elemental	In Pyrites	In Other* Forms	Total	All Forms
USA	7,126	1,290	360	505	9,281	10,000
USSR	–	1,400	1,850	990	4,240	4,700
Canada (shipments)	–	2,266	165	537	2,968	3,000
Japan	–	318	1,380	837	2,535	2,550
France	–	1,649	37	142	1,828	1,800
Mexico	1,824	52	–	25	1,901	1,700
Poland	**	600**	99	94	793	1,300**
Spain	–	41	1,133	28	1,202	1,200
China (Mainland)	–	150	720	81	951	1,100
Italy	–	81	608	207	896	950
West Germany	–	106	279	251	636	640
Britain	–	46	–	483	529	570
Cyprus	–	–	450	–	450	450
East Germany	–	135	60	172	367	380
Finland	–	101	97	166	364	370
Norway	–	1	310	30	341	360
Others	–	358	2,016	1,065	3,439	3,430
Total	8,950	8,594	9,564	5,613	32,721	34,500

Sources: US Bureau of Mines, The Journal of World Sulphur, Dominion Bureau of Statistics, and Canadian Minerals Yearbook 1967.
* Sulphur from smelter gases, gypsum-anhydrite, spent oxide, and others.
** Some Polish sulphur included under other elemental is Frasch origin.
^e Estimates except Canada and USA; – Nil.

continued start-up difficulties have delayed production. In the same general region of West Texas, Duval Corporation is scheduled to begin production from a deposit in Culberson County in August 1969.

Frasch sulphur production in Mexico decreased slightly from the 1967 level of 1.8 million metric tons to 1.6 million metric tons. Production of elemental sulphur recovered from sour natural gas in France also decreased marginally from 1.636 million metric tons in 1967 to 1.607 million metric tons in 1968. World pyrite production increased by some 2.5 per cent largely due to increased output in Japan, South Africa, Italy and Spain. Production of sulphur in other forms, largely contained in smelter gases increased by about 5 per cent.

The most significant change in world sulphur markets and trading patterns was caused by the increased availability of Polish sulphur from two new native sulphur deposits. Major new production facilities are in progress in addition to the established operations at Piaseczno, Grzybow and Jeziorko. A new open-pit mine at Machow is expected to be in operation in the spring of 1969 and Frasch type production may have already started at a new location. Polish sulphur production in 1968 is estimated at 1.3 million metric tons and could easily reach 1.75 million tons in 1969. Exports in 1968 are estimated at 960,000 metric tons of which some 700,000 metric tons entered markets in western Europe, Africa, Asia, Oceania and Latin America. Sales of Polish sulphur in Europe were largely responsible for easing the supply-demand imbalance which existed in that area in 1967.

OUTLOOK

The world sulphur supply-demand imbalance was resolved in the first half of 1968 due in large part to slackening consumer demands in the fertilizer industry and large production increases in Canada and Poland. These same two countries will contribute nearly one half the anticipated increases in world sulphur production in 1969. In view of these expected increases in output and the mounting producer inventories both in the United States and Canada, sulphur markets are likely to remain soft at least in the near term. Sulphur prices weakened in the latter part of 1968 and early 1969 and a downward pressure on prices is likely to continue. Unlike many other major commodities, sulphur can be stored in the open for long periods of time without seriously affecting quality. Available stocks of sulphur at somewhat lower prices than those paid during recent years are likely to result in diminishing interest in developing sulphur resources from less economical processes such as extraction from gypsum. Further, though sometimes economically unattractive, the need to remove sulphur from metallurgical and other industrial waste gases to combat air pollution will contribute significant quantities of sulphur to world markets in the immediate future. It is anticipated that Polish sulphur will make further inroads into markets formerly served by North American and European producers.

PRICES

Canadian prices quoted in *Canadian Chemical Processing*, October 1968, were as follows:

Sulphur, elemental, f.o.b. works, contract, car lots, per long ton	\$34.00 - \$41.00
Sulphuric acid, f.o.b. plants, East 66° Be, tanks, per short ton	\$31.00

United States prices quoted in *Oil, Paint and Drug Reporter*, December 30, 1968, were as follows:

Sulphur, crude, domestic, dark, bulk, f.o.b. cars, mines, per long ton	\$41.00
Sulphur, export bright, long-term contracts, f.o.b. vessels, Gulf ports, per long ton	\$41.00
Sulphuric acid 66° Be, tanks, f.o.b. works, per short ton	\$32.30

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 compounds containing sulphur with reductions beginning on January 1, 1968. Some of the reductions made by Canada and United States are as follows:

CANADA		
(Most Favoured Nation Rates)		
		Dec. 31, 1968
Sulphur all kinds other than sublimited, precipitated and colloidal sulphur	free	free
Sulphuric acid	22½¢/ 100 lb	15%
UNITED STATES		
Pyrites	free	free
Elemental sulphur	"	"
Sulphuric acid	"	"
Sulphur compounds	9%	8%
Sulphur dioxide	11%	10%

Sources: The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa. Tariff Schedules of the United States, Annotated 1969, TC Publication 272.

Talc and Soapstone; Pyrophyllite

D.H. STONEHOUSE*

Talc is a hydrated magnesium silicate which occurs as a secondary mineral formed by the alteration of other magnesium silicates such as serpentine and pyroxene, or by the alteration of carbonates. Commercial ground talc sometimes contains small amounts of the original unaltered minerals. Talc is soft and flaky, has a greasy feel or "slip" and grinds to a near-white powder. It is relatively inert chemically, has a high fusion point and low electrical and thermal conductivity. In broad definition, talc is an inclusive term covering all gradations from the pure mineral to soapstone which could contain only 50 per cent of the mineral talc. Distinction between various types is often vague and the end use to which a ground product is successfully put is often a means of identifying its grade, e.g., cosmetic grade, pharmaceutical grade, ceramic grade or paint grade.

Soapstone is essentially an impure talcose rock from which blocks and crayons can be readily sawn.

Pyrophyllite, a hydrous aluminum silicate, is physically similar to talc. An alteration product of siliceous rocks, it is often accompanied by sericite and quartz. The colour, near-white, is generally acceptable to industry but the content of impurities must be controlled.

Shipments of talc and soapstone from Canadian producers increased during 1968, resulting in an increase in value of shipments of these commodities of 18.9 per cent to an estimated $564,000. The value of pyrophyllite shipped from the single producer also increased; all production is exported to the United States for the manufacture of ceramic tile.

*Mineral Resources Branch.

OPERATIONS IN CANADA

TALC

At South Bolton, Quebec, about 60 miles southeast of Montreal, Baker Talc Limited produces talc and soapstone from an underground mine. The talc deposits in this area were formed by the alteration of serpentinzed peridotite and contain, in addition to talc, serpentine, magnesite and iron-bearing minerals such as chlorite and pyrrhotite.

Ore mined at South Bolton is milled at Highwater, about 10 miles south of the mine site. Processing consists of primary and secondary crushing, finegrinding and air classification. The products to date have been relatively low grade. Shipments of ground talc are made in sacks or in bulk for use as a filler in asphalts and rubber, as a dusting compound for roofing products, as a component of auto-body patching compounds and wall-joint compounds and as a carrier or coating for insecticides. Both rough and sawn blocks of soapstone are sold for sculpturing.

Baker Talc Limited officials have been associated with the development of the Jones High Intensity Wet Magnetic Separator and with the support of the federal Department of Industry's Program for Advancement of Industrial Technology (PAIT), experiments were conducted during 1967-68 to upgrade the talc product, utilizing "micro-magnetic separation" techniques as applied through the Jones Separator. The company was satisfied that the talc could be beneficiated and that a high-grade product suitable for paint manufacture, paper coating,

TABLE 1

Talc and Soapstone; Pyrophyllite Production, Trade and Consumption

	1967		1968p	
	Short Tons	$	Short Tons	$
Production (shipments)				
Talc and soapstone				
Quebec[1]	..	228,695	..	225,000
Ontario[2]	..	228,650	..	339,000
Total	..	457,345	..	564,000
Pyrophyllite				
Newfoundland	..	443,640	..	630,000
Total Production Value		900,985		1,194,000
Imports (talc)				
United States	25,275	1,161,000	27,665	1,334,000
Italy	1,207	88,000	579	41,000
Total	26,482	1,249,000	28,244	1,375,000
			1966	1967
Consumption (ground talc, available data)				
Ceramic products			8,412	6,754
Paints and wall-joint sealers			6,587	6,500
Roofing			6,315	6,557
Paper and paper products			2,164	2,968
Rubber			1,617	1,264
Insecticides			860	620
Toilet preparations			719	761
Cleaning compounds			685	644
Pharmaceutical preparations			451	423
Linoleum and tile			1,967	363
Other products[3]			5,264	5,689
Total			35,041	32,543

Source: Dominion Bureau of Statistics.
[1]Ground talc, soapstone blocks and crayons; [2]Ground talc; [3]Chemicals, foundries, gypsum products and other uses.
pPreliminary; .. Not available.

cosmetics, pharmaceuticals and fillers can be produced, and by the end of 1968, it decided to expand existing plant facilities to incorporate a Jones Separator in the beneficiation circuit.

Broughton Soapstone & Quarry Company, Limited quarries talc and soapstone from two separate 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 metal-workers' crayons and blocks for sculpturing.

Underground mining and surface milling operations at Madoc, Ontario, by Canada Talc Industries Limited, produce several different grades of talc. The deposits in this district were formed by the alteration of a near-white, dolomitic marble and consist primarily of talc, tremolite and dolomite in various proportions. Ground products are near-white and naturally low in iron but are limited in use because they contain variable amounts of dolomite. A quantity of high-grade, mine-run, crude talc was shipped to South Plainfield, New Jersey during the year, where beneficiation produced pharmaceutical-grade products. Canada Talc's own high-grade, white, finished product is used as a filler in the paint industry.

PYROPHYLLITE

Newfoundland Minerals Limited, a subsidiary of American Olean Tile Company, Inc. mines a high-quality pyrophyllite by open-pit methods at Long Pond near Manuels, Newfoundland. Crushing, screening, and sampling at the quarry site permit stockpiling at tidewater to be done on a quality basis. Subsequent blending during ship-loading makes it possible to send uniform cargoes to the parent company at Lansdale, Pennsylvania where the entire production is used in the manufacture of ceramic tiles. Raw material specifications for this use are very exacting.

Interpretation of the geology of the Manuels area indicates formation of pyrophyllite and quartz-pyrophyllite schist during hydro-thermal alteration of sheared rhyolite lavas near their contacts with granite. The pyrophyllite occurrence appears to have been influenced both by fracturing near the granite boundary and the acidic composition and sheared condition of the country rock.

TRADE AND CONSUMPTION

Exports of talc and soapstone have been increasing slightly during the past few years. However, from a value point of view, Canada is a net importer of talc, soapstone and pyrophyllite, because of importing the more expensive, higher-quality grades which are as yet unavailable from Canadian producers. Imports have come mainly from the United States and Italy and are for use in the paint, ceramics, paper and cosmetics industries.

Commercial talc is used mostly in a fine-ground state, although soapstone is used to a limited extent in the massive or block form. There are many industrial applications for ground talc but major consumption is limited to less than a dozen industries.

Higher-quality talc is used as an extender pigment in paints, a filler and coater in the manufacture of papers and an important raw material in the ceramics industry. Specifications for a talc pigment, as established in ASTM Designation D605-66T, relate to chemical limits, colour, particle size, oil absorption and consistency of, and dispersion in, a talc-vehicle system. A low content of carbonates, a near-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.

TABLE 2

Production and Trade, 1959-1968
(short tons)

	Production[1]			Imports	Exports
	Talc and Soapstone		Pyrophyllite (all exported)	Talc	Talc
1959	24,733		14,443	18,501	2,053
1960	21,411		20,225	19,153	1,660
1961	23,691		24,425	20,205	2,000[e]
1962	23,367		22,794	24,148	2,300[e]
1963	22,467		31,783	27,539	2,200[e]
1964	25,316		32,816	31,598	2,600[e]
1965	22,703		30,134	27,858	3,500[e]
1966	29,596		40,548	24,918	. .
1967		60,665[2]		26,482	. .
1968[p]		77,300[2]		28,244	. .

Source: Dominion Bureau of Statistics.
[1]Producers' shipments. [2]Total talc, soapstone and pyrophyllite. Breakdown of tonnages not available for publication commencing 1967.
[e]Estimated, not available as a separate trade class after 1960; [p]Preliminary; . . Not available.

Paper manufacturers require talc free from chemically active substances and having high reflectance, high retention in the pulp and low abrasiveness. Micronized talc provides a high-gloss finish on coated paper for printing.

The ceramics industry specifies talc of fine particle size containing no impurities that would discolour the fired product. Both translucence and toughness of ceramics are increased by the addition of talc.

Talc of high purity is used in cosmetic and pharmaceutical preparations. In this application, properties of fluidity and absorption permit mixing with the vegetable constituents used in cosmetics, and therefore fine, flaky particles are necessary.

Lower-grade talc is used as a dusting agent for asphalt roofing and gypsum board; a filler in joint-sealing compounds for dry-wall construction, floor tile, asphalt pipeline enamels and auto-body patching compounds; a diluent for dry insecticides; and a filler and dusting agent in the manufacture of rubber products. Particle size is important; colour and impurity content are generally of little concern although for asphalt pipeline enamels, a low carbonate content is specified to avoid a reaction with soil acids.

Because of its unusual characteristics, talc has a number of minor applications, including use in cleaning compounds, polishes, electrical cable, plastic products, foundry facings, adhesives, linoleum, textiles and oil-absorbent preparations.

Particle-size specifications for most uses require the talc to be basically 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 resistance to heat and softness, it is still used by metal-workers 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.

Reliable consumption statistics are difficult to obtain because of the many grades of talc products and their great variety of uses. Established suppliers dominate the market. Because some talc is a comparatively low-cost commodity, increased prices can result in the use of substitutes. Alternative materials

TABLE 3

World Production of Talc, Soapstone and Pyrophyllite, 1966-1968
(short tons)

	1966	1967	1968[e]
Japan	1,222,425	1,509,663	1,600,000
United States	895,045	902,512	939,000
USSR[e]	395,000	408,000	. .
France	213,848	215,000	230,000
India	172,284	. .	. .
China (mainland)[e]	165,000	165,000	. .
Rumania[e]	127,000	143,000	. .
Italy	124,207	134,482	100,000
South Korea	119,379	135,443	. .
Norway	86,366	88,000[e]	90,000
Austria	84,110	87,000	90,000
Canada	70,144	60,665	77,300
Other countries	356,445	168,042	. .
Total	4,031,263	4,016,807	4,580,000

Source: U.S. Bureau of Mines, Minerals Yearbook, 1967. 1968 figures U.S. Bureau of Mines Data Summaries January, 1969.
[e]Estimated; . . Not available.

for many applications are: kaolin, fuller's earth, limestone, feldspar, mica, gypsum, kyanite, quartz and wollastonite.

WORLD REVIEW

Deposits of talc are widely distributed throughout the world but they have been commercially developed in only the more industrialized countries. Because of the particular qualities of each of the many grades of talc, shipments of both raw talc and of finished products are made over extensive distances to supply the required product for a specific use.

The United States is second to Japan in total production of talc, soapstone and pyrophyllite. Canada ranks twelfth among world producers.

PRICES

United States talc prices according to *Oil, Paint and Drug Reporter*, December 30, 1968, were as follows:

Canadian	- ground, bags, carlot, f.o.b. mines	per ton	- $20.00 - $35.00
Vermont	- domestic, ordinary, off-colour, ground, bags, carlot, f.o.b. works	per ton	- $21.40
California	- domestic, ordinary, off-colour, bags, carlot, f.o.b. works	per ton	- $34.00 - $39.50
New York	- domestic, fibrous, ground, bags, carlot, f.o.b. works	per ton	- $31.00 - $36.00

TARIFFS

	British Preferential	Most Favoured Nation	General
CANADA			
Talc or soapstone	10%	15%	25%
Micronized talc	free	5%	25%
Pyrophyllite	free	free	25%
Talc for use in manufacture of ceramic tile	free	free	25%
UNITED STATES			
Talc, steatite and soapstone			
Crude and not ground			
Jan. 1, 1968		.02¢ per lb	
Jan. 1, 1969		.02¢ " "	
Ground, washed, powdered or pulverized			
Jan. 1, 1968		10.5%	
Jan. 1, 1969		9.5%	

Reductions under the Kennedy Round of the General Agreement on Tariffs and Trade (GATT), that was convened in 1964 and concluded in 1967, were scheduled to lower United States tariffs to .02¢ and 6% respectively on and after Jan. 1, 1972.

Sources: The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa.

Tariff Schedules of the United States, Annotated (1969) TC Publication 272.

Tin

W.H. JACKSON*

DOMESTIC INDUSTRY

All Canadian industrial requirements of tin are purchased abroad as there are no domestic smelters and production of concentrate is negligible. Imports of tin in 1968 were 4,300 long tons** valued at $14.9 million. The major consumers require high quality tin and Straits brand from Malaysia continues to be the main source.

Consumption of primary tin declined slightly to 4,251 tons from 4,812 tons in 1967. The decrease was distributed among all major uses as shown in Table 1. Consumer stocks totalled 389 tons on December 31, 1968 a decrease of 179 tons from 1967.

Cominco Ltd. is the only Canadian producer of tin concentrate. Byproduct production from the milling of lead-zinc ores at Kimberley, British Columbia, is exported for smelting mainly to Mexico. In addition, a lead-tin alloy is obtained from the treatment of lead bullion dross in the indium circuit of the Trail, British Columbia, smelter of Cominco Ltd. 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).

Exploration for tin was confined to further drilling, by Sullico Mines Limited, of the Mount Pleasant prospect in New Brunswick.

Possible further recovery of cassiterite from lead-zinc ores depends on advances in ore treatment techniques and the economics of processing. Fine-grained cassiterite, which cannot be recovered at present, is a mineralogical component of some sections of the copper-zinc-lead-silver orebody near Timmins, Ontario, of Ecstall Mining Limited, and is also present in minor quantities in the zinc-lead ores of Brunswick Mining and Smelting Corporation Limited in New Brunswick.

Tinplate accounts for 55 per cent of tin consumption in Canada. There are two producers: Dominion Foundries and Steel, Limited and The Steel Company of Canada, Limited, both at Hamilton, Ontario. Improvements in the quality of steel used in tinplate manufacture and control of the electroplating process resulted in a better product requiring less tin which led to the cessation of hot-dip tinplate production at the end of 1966. All Canadian output of tinplate, estimated at 429,000 tons for 1968, is now electrolytic. Estimated consumption of tin in the manufacture of tinplate was 2,360 tons.

The manufacture of solder accounts for 30 per cent of consumption, the two main producers being The Canada Metal Company, Limited and Federated Metals Canada Limited. The automotive industry is the main consumer of solder and of bearing alloys.

In Canada, M & T Products of Canada Limited produces a number of tin chemicals from the detinning of high-quality tinplate scrap from can-making operations.

A new application, requiring small tonnages, is in the production of plate glass. Pilkington Glass Limited has a plant at Scarborough, Ontario with a capacity of 125,000 tons of glass annually. A further 175,000-ton-capacity is under construction. One surface is cast perfectly flat on a bed of molten tin and the product does not require subsequent grinding and polishing.

* Mineral Resources Branch.
**Long tons are used throughout this review.

TABLE 1

Canada, Tin Production, Imports and Consumption, 1967-68

	1967		1968P	
	Long Tons	$	Long Tons	$
Production				
Tin content of tin concentrates and lead-tin alloy	195	621,682	150	552,993
Imports				
Blocks, pigs, bars				
Malaysia	2,886	10,508,000	3,030	10,367,000
United States	636	2,359,000	924	3,338,000
Thailand	1,020	3,714,000	315	1,081,000
Nigeria	–	–	25	85,000
Britain	6	21,000	6	21,000
Total	4,548	16,602,000	4,300	14,892,000
Tinplate				
United States	3,730	644,000	4,531	820,000
Britain	239	117,000	260	95,000
Total	3,969	761,000	4,791	915,000
Tin, fabricated materials, n.e.s.				
United States	15	61,000	16	64,000
Britain	...	3,000	...	
Total	15	64,000	16	64,000
Exports				
Tin in ores and concentrates				
Mexico	125	458,000	104	359,000
United States	32	22,000	13	15,000
Britain	167	9,000	–	–
Total	324	489,000	117	374,000
Tinplate scrap				
United States	21,053	633,000	14,664	500,000
Republic of South Africa	–	–	19	....
Total	21,053	633,000	14,683	500,000
Consumption				
Tinplate and tinning	2,513		2,423	
Solder	1,636		1,264	
Babbitt	234		180	
Bronze	194		205	
Galvanizing	11		17	
Other uses (including collapsible containers, foil, etc.)	224		162	
Total	4,812		4,251	

Source: Dominion Bureau of Statistics.
PPreliminary; ... Less than one ton; .... Less than one thousand dollars; n.e.s. Not elsewhere specified; – Nil.

WORLD DEVELOPMENTS

The main centres of tin mining are situated in developing countries but consumption is concentrated in the major industrial countries. A common interest in market stability in the postwar period led first to a Study Group then to the First International Agreement in 1956 under the auspices of the United Nations. The tin industry is characterized by a low long-term growth trend in consumption and a fluctuating price for the metal. These characteristics are related to the long supply pipeline and the recurrent effects on supply of national or international events.

The Third International Tin Agreement is operative for a five-year period beginning July 1, 1966. Its main object is the consideration of short-term problems of price and supply. Decisions that affect price and supply are made with regard to long-term trends. Consumer and producer members have an equal number of votes in a governing body, the International Tin Council. Canada is a signatory to the Agreement and, in proportion to its consumption, has 62 out of the total of 1,000 votes allocated to consumer members. The 17 consumer members in 1968 accounted for 86,700 tons out of total consumption amounting to 169,700 tons. The total does not include most communist countries as the requisite data is not available. The United States (58,120 tons) and West Germany (11,582 tons) are the main non-member countries among western consuming nations. Producer members are Bolivia, Congo (Dem. Rep.), Indonesia, Malaysia, Nigeria, and Thailand. Counted together, producer and consumer members of the Council account for 94 per cent of the non-communist production of tin-in-concentrate.

TABLE 2

Canada, Tin Production, Imports and Consumption, 1959-68
(long tons)

Year	Production[1]	Exports[2]	Imports[3]	Consumption[3]
1959	334	. .	4,183	4,233
1960	278	. .	3,768	3,880
1961	500	479	3,525	3,953
1962	291	287	2,274	4,507
1963	414	800	4,193	4,942
1964	157	329	4,849	4,822
1965	168	216	4,993	4,892
1966	317	337	4,254	4,972
1967	195	326	4,548	4,812
1968[p]	150	118	4,300	4,251

Source: Dominion Bureau of Statistics.
[1] Tin content of tin concentrates shipped plus tin content of lead-tin alloys produced. [2] Tin content of tin concentrates exported. [3] Tin metal.
[p] Preliminary; . . Not available.

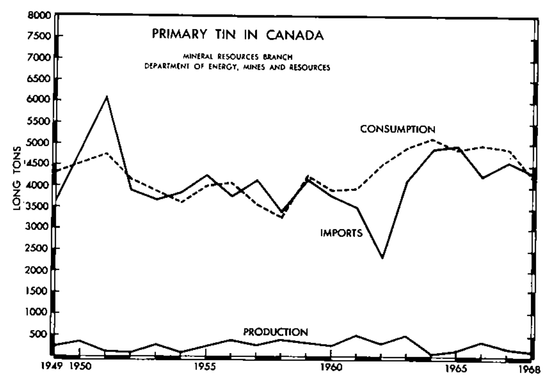


TABLE 3

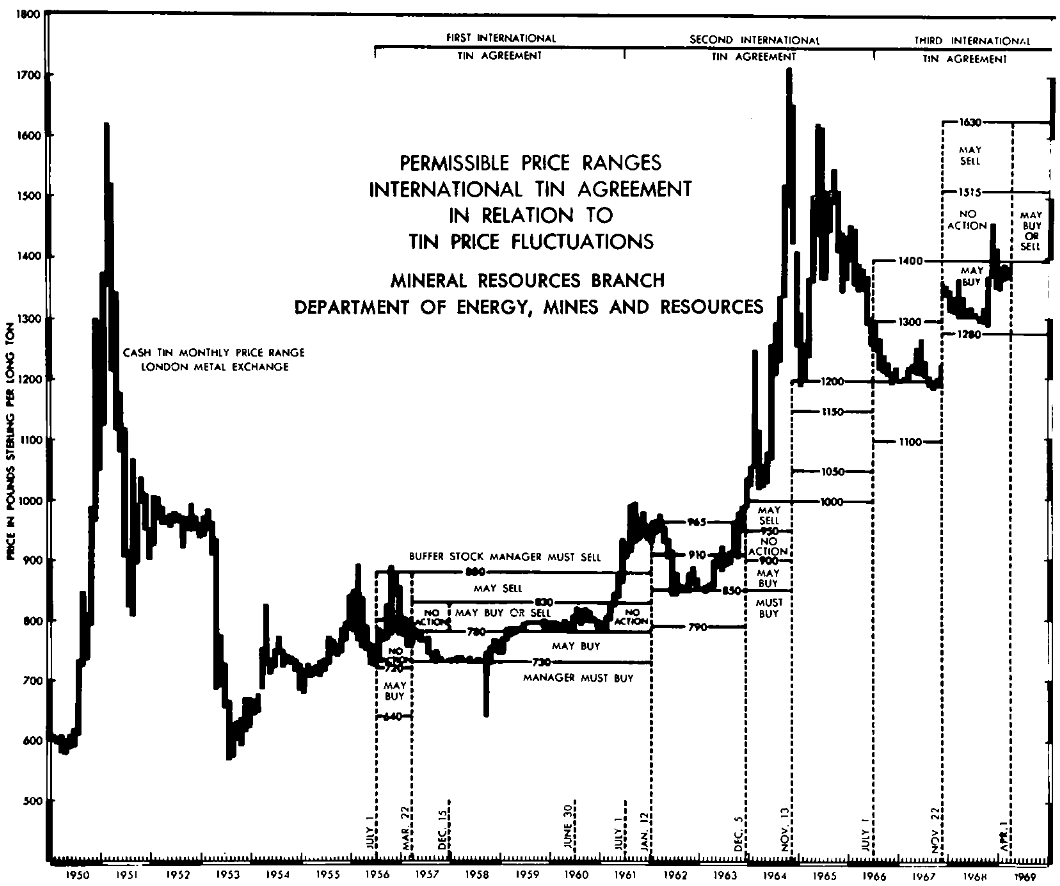
Estimated World* Production of Tin-in-Concentrates, 1960, 1967-68
(long tons)

	1960	1967	1968
Malaysia	51,979	72,121	75,069
Bolivia	20,219	27,283	29,101
Thailand	12,081	22,490	23,601
Indonesia	22,596	13,601	16,632
Federation of Nigeria	7,675	9,340	9,649
Congo (Dem. Rep.)	9,202	7,013	7,377
Australia	2,176	5,600	6,777
Total, including countries not listed	136,500	171,900	182,700

Source: International Tin Council, Statistical Bulletin.
*Excludes communist countries, except Czechoslovakia.

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 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.

The accompanying graph shows tin price fluctuations from 1951 to 1968 in relation to price ranges considered desirable by Council at various periods.



Throughout 1964 and 1965 prices exceeded these 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.

Significant production increases were recorded for Malaysia, Bolivia and Thailand from 1960 to 1968 (Table 3). In 1968, efforts were continuing to redevelop mines in Indonesia and the Congo, those in Nigeria were experiencing difficulty in maintaining production. At the end of 1968, the world tin position summarized in Table 5 indicated a small but persistent surplus of mine production over consumption. To correct the imbalance Tin Council declared a control period for the last quarter in 1968 and the first quarter of 1969. Further decisions will depend on the forward statistical position and the market situation. Beginning April 1, 1969, the Buffer Stock Manager was authorized to buy or sell tin in the middle price range.

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. Sales from the United States stockpile declined in 1966 and were nominal in 1967 and 1968 as prices declined below the effective General Services Administration selling price of $1.54 (US) a pound. The United States stockpile originally held 348,310 tons in 1962, before disposals began. The stockpile objective was 200,000 tons at the end of 1968, which was raised on March 27, 1969 to 232,000 leaving 25,524 tons authorized and available for disposal. A review of disposal policy was under way.

TABLE 4

Estimated World* Production of Primary Tin Metal, 1960, 1967-68
(long tons)

	1960	1967	1968
Malaysia	76,366	76,328	88,185
Britain	26,374	23,317	24,933
Thailand	218	26,551	24,434
Netherlands	6.393	13,739	7,983
Federation of Nigeria	–	9,131	9,843
Belgium	8,255	4,193	4,799
Indonesia	1,977	1,481	4,560
United States	13,500	3,049	3,453
Australia	2,255	3,594	3,692
Spain	464	1,523	2,062
Brazil	1,312	2,100	2,100
Japan	1,189	1,671	1,859
Congo (Dem. Rep.)	2,507	1,800	1,800
Total, including countries not listed	145,900	174,100	184,300

Source: International Tin Council, Statistical Bulletin.
*Excludes communist countries, except Czechoslovakia.
–Nil.

TABLE 5

Estimated World* Tin Position, 1966-68
(long tons)

	1966	1967	1968
Ore Supply			
Production of tin-in-concentrates	164,000	171,900	182,700
Stocks at year's end	24,800	23,200	24,300
Primary Metal Supply			
Smelter production of tin metal	155,600	174,100	184,300
Net sales to centrally-planned countries	2,100	5,100	6,400
Government stockpile sales	16,800	6,146	3,495
Buffer stock, sales +, purchases –	35-	4,720-	6,535-
Commercial stocks at year's end	51,300	53,300	62,200
Primary metal consumption	166,100	164,300	169,700

Source: International Tin Council, Statistical Bulletin.
*Excludes communist countries, except Czechoslovakia.

The position of communist countries continues to be an uncertain factor in predicting the supply-demand balance. Net exports to these countries appear to be increasing. China (People's Rep.) is a major producer whose output is in the order of 25,000 tons annually. East Germany produces 1,200 tons annually and the USSR 33,000 tons.

USES

Tin metal is unequalled for a protective hygienic coating on steel. The manufacture of tinplate represents the largest market for tin. Available world data indicates that 73,400 tons were used in 1968 to produce 11.5 million tons of tinplate. The tin coating on the steel varies with the product mix of tinplate plants from 0.25 pound per base box for electrolytic tinplate up to 1.25 pounds for the hot-dip process. Tinplate is sold by the base box (31,360 square inches). There is currently no substitute for tinplate in most container applications involving food processing but for beverages chrome-plated steel or aluminum are increasingly competitive.

The chemicals, stannous chloride and stannous sulphate as well as sodium stannate and potassium stannate, are used as an electrolyte in the tinplate process. The chloride stabilizes the colour and perfume in soap. Stannic oxide is an opacifier in enamels. Stannic chloride is the basic chemical in the manufacture of organotin compounds. Such compounds are used as fungicides and to stabilize chlorinated transformer oils and rubber base paints. The di-octyl and di-butyl compounds are stabilizers in polyvinyl chloride plastics, which have growing importance in container applications.

In recent years, a change in glass technology resulted from the development of a method of making plate glass by floating molten glass on a bath of tin.

The alloy applications of tin have a long tradition. A relatively new application is the use of tin in cast irons for automobile engine blocks. The solders are indispensable for joining the side-seam on cans, for motor-car radiator cores, and for ensuring continuity in electrical contacts. Babbitt and white metal alloys are used for bearings and so are aluminum-tin alloys, which have a higher fatigue strength. The tin bronzes containing over 12 per cent tin are mainly used for castings; wrought alloys contain less tin. The gun-metals contain copper, tin, zinc, and sometimes lead to improve machinability. Continuous casting of standard shapes has reduced fabrication costs and caused renewed interest in bronze as an engineering material. Fusible alloys of tin, bismuth, lead, and cadmium are used in safety devices. Die-casting alloys of tin, antimony and copper have applications in jewellery. Modern pewter is essentially Britannia metal containing 90-95 per cent tin 4.8 per cent antimony and 1-2 per cent copper. As a minor alloying agent in other metals tin has a wide use. While aluminum has replaced tin in most foil and tube applications it is still used in some condensers and also in containers for pharmaceutical products.

PRICES

The average price in cents (US) for a pound of tin in 1968 on major markets was as follows: 1) Straits brand, delivered ex-works, Penang, Malaysia, 138.56 equivalent to £1293.2 per long ton; 2) Prompt tin, New York, 148.11 (£1382.36); and 3) Cash tin, 141.78 (£1323.3) and Forward tin, 142.24 (£1327.6), London, England, following Sterling devaluation. The difference in these market prices is nominally transportation and insurance costs plus the cost of financing. Straits ex-works is deliverable in 60 days and London Forward in three months. The other prices are for immediate delivery.

In Canada, larger consumers put their requirements to tender, or negotiate a supply contract, and over a period the price paid is the equivalent of the New York price.

Tin concentrate prices are negotiated between the mine producer and the smelter operator. Smelting charges increase rapidly as the concentrate grade declines and are affected also by such impurities as Fe, WO_3, S, As and others. The *Metal Bulletin* quotes nominal values for concentrate delivered to smelters in Britain, specifying that for concentrate assaying 70 to 75 per cent tin, payment is made for the metal content less 1 unit (22.4 lb), less a smelting charge of £15 to £12 a long ton of concentrate treated. For concentrate assaying 40 to 65 per cent tin the unit deduction varies from 1.6 to 1.0 units and the smelting charge from £29 to £23. For concentrate assaying 20 to 30 per cent tin the smelter charge is £70 to £65, which includes the unitage deduction.

TARIFFS

Most Favoured Nation Tariff

	1969*
CANADA	
Ores of metals, n.o.p.	free
Tin in blocks, pigs, bars, or granular forms	free
Tin strip waste and tin foil	free
Collapsible tubes of tin or lead coated with tin	22
Tinplate	14
Tin oxides	15
UNITED STATES	
Tin ore and black oxide of tin	free
Unwrought tin other than alloys	"
Unwrought tin alloys	"
Tin waste and scrap	"
Tinplate	
Valued not over 9.4¢ per lb	8.5%
Valued over 9.4¢ per lb	0.8¢/lb
Tin foil	28%

Source: Canada, The Customs Tariff and Amendments, Dept. of National Revenue; Tariff Schedules of United States Annotated (1969).

*Effective date January 1. For both Canada and United States varying tariffs exist on tin chemicals and compounds and also on manufactured articles of tin.

Titanium and Titanium Dioxide

G.P. WIGLE*

Quebec Iron and Titanium Corporation (QIT) established a new annual production record in 1968 with an output of 600,773 long tons of titania slag (70-72 per cent TiO_2) and 410,085 long tons of co-product iron.

Canada's titanium industry is based principally on the mining and processing of ilmenite for the production of titanium dioxide (TiO_2) slag used in the pigment industry. Minor amounts of ilmenite are mined intermittently for use as heavy aggregate in special concrete.

Producers of titanium-dioxide pigment are the major consumers of the growing output of the titanium mineral industry but titanium metal production continues to expand in response to requirements of the commercial and military aircraft industries.

PRODUCTION

CANADA

Ilmenite is mined by open-pit methods in the Lac Tio-Allard Lake area of Quebec by Quebec Iron and Titanium Corporation. The ilmenite, crushed to minus 3 inches, is transported 27 miles by rail to Havre St. 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 known reserves of ilmenite, with indicated reserves averaging 35 per cent TiO_2 and 40 per cent iron. The ilmenite occurs, with finely disseminated hematite (Fe_2O_3) as 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 spirals and 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 wholly-owned subsidiary of National Lead Company, New York, operated its titanium dioxide pigment plant at Varennes, Quebec, at full capacity throughout 1968. The major raw material, titanium dioxide slag, was obtained from Quebec Iron and Titanium Corporation. Sulphur for the manufacture of sulphuric acid is the other principal raw material. While the bulk of the pigment output was sold in the domestic market, substantial quantities were exported, particularly to Britain. Construction of the company's new chloride process unit was nearly complete at the end of 1968 and it was expected to be in full production by mid-1969. The chloride unit adds 10,000 tons a year to the capacity of the Varennes plant which is currently producing 30,000 tons a year using the sulphate process.

Tioxide of Canada Limited at Sorel, Quebec is a wholly-owned subsidiary of British Titan Products Limited, London, England. The company's productive capacity was increased from 22,000 tons to 27,000 tons of pigment a year in 1966 and the plant was operated at full capacity during 1968. Most of the output was sold in Canada but significant quantities were exported to Britain, Europe and the United States.

*Mineral Resources Branch.

TABLE 1

Canada – Titanium Production and Trade

	1967		1968P	
	Short Tons	$	Short Tons	$
Production[1] shipments				
Titanium dioxide	. .	23,737,330	. .	24,574,000
Imports				
Titanium dioxide, pure				
United States	681	376,000	951	502,000
Britain	324	146,000	858	367,000
West Germany	259	107,000	337	142,000
Japan	1	1,000	131	43,000
Spain	265	85,000	110	35,000
Other countries	86	34,000	–	–
Total	1,616	749,000	2,387	1,089,000
Titanium dioxide, extended				
United States	9,763	1,860,000	9,697	1,836,000
Titanium metal[2]				
United States	2,078	10,655,000	183	1,643,000
Britain	82	299,000	30	113,000
Japan	7	22,000	20	56,000
Total	2,167	10,976,000	233	1,812,000
Exports[3] to the United States				
Titanium metal, unwrought, incl. waste and scrap	229	948,123	237	674,900
Titanium metal, wrought			72	455,883
Titanium dioxide	1,750	. .	2,624	1,064,957

Source: Dominion Bureau of Statistics.

[1]Producers shipments of slag, TiO_2 content. [2]In 1967 titanium metal and alloys, in 1968 titanium metal only. [3]As reported by the U.S. Department of Commerce, U.S. Imports for Consumption, Report FT 135. No identifiable classes are available from Canadian export statistics.

PPreliminary; –Nil; . .Not available.

Titanium dioxide pigment is manufactured in both anatase and rutile grades. Both grades are nearly pure TiO_2 but differ in opacity because of different crystal structure and index of refraction. Consumption of titanium pigments in Canada was an estimated 45,000 tons in 1968. Prices of regular anatase and rutile pigment remained at $25 and $27 per 100 pounds respectively, the same as established on April 1, 1967.

Atlas Titanium Limited, Welland, Ontario, a subsidiary of Rio Algom Mines Limited, melts titanium and its alloys in a consumable electrode vacuum arc furnace and processes the metal into various mill products for sale in domestic and foreign markets. 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.

TABLE 2

Titania Slag and Iron Production,
Quebec Iron and Titanium Corporation, 1967-68
(long tons)

	1967	1968
Ore mined	1,630,589	1,501,634
Ore beneficiated	1,287,713	1,424,552
Ore smelted	1,091,651	1,232,354
Titania slag produced	537,906	600,773
Iron produced	366,660	410,085

Source: QIT.

Dominion Magnesium Limited, near Haley, Ontario, produces magnesium, calcium. and other mineral products. The company's production of co-products included 4,000 pounds of titanium in 1968.

UNITED STATES

The United States is the largest producer and consumer of ilmenite; it is also the largest consumer of rutile with 98 per cent of its supply coming from Australia, the principal of the few producers of rutile.

Ilmenite is produced in the United States at six mining operations in New York, Florida, Georgia, Virginia and New Jersey. Over half is produced in New York state and about one third in Florida. Domestic and imported ilmenite is consumed by some 100 firms of which six titanium pigment producers in the eastern United States use 95 per cent of the total. Rutile was produced in Virginia in 1968 by only one company. About 90 per cent of titanium metal used went into products for military and civilian aircraft, missiles, and spacecraft; the remainder was used in the chemical industry, and in marine and other applications.

TABLE 3

Canadian Titanium Production, Trade and Consumption, 1959-68
(short tons)

	Production		Imports			Consumption	
	Ilmenite[1]	Titanium Dioxide Slag[2]	Titanium Dioxide Pure	Titanium Dioxide Extended[4]	Total Titanium Dioxide Pigments[3]	Titanium Dioxide Pigments[5]	Ferro-titanium[6]
1959	626,310	234,670	. .	. .	30,598	35,865	101
1960	967,373	386,639	. .	. .	26,896	36,394	257
1961	1,155,977	463,316	. .	. .	26,621	37,098	198
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	43,431	49
1967	1,442,238	602,455	1,616	9,763	11,379	. .	54
1968p	1,595,498	672,866	2,387	9,697	12,084	. .	. .

Sources: Dominion Bureau of Statistics, and company reports.

[1]Producers' shipments of ilmenite from Allard Lake and St. Urbain area, from company reports. [2]Gross weight of 70-72% TiO_2 slag produced, from company reports. [3]1959 to 1961, titanium and oxide pigments containing not less than 14% by weight of TiO_2; from 1962 on, includes pure and extended TiO_2. [4]Approximately 35 per cent TiO_2. [5]Includes pure and extended TiO_2 pigments. [6]Ti content.

pPreliminary; . .Not available.

AUSTRALIA

Preliminary estimates indicate that Australia's rutile production for 1968 could be some 300,000 long tons compared with 274,963 long tons in 1967. Ilmenite production is also expected to show an increase in 1968 over the 1967 output of 538,673 long tons of concentrate.

TABLE 4

Salient Titanium Statistics, United States, 1967-68
(short tons)

	Ilmenite		Rutile		Titanium[2]	
	1967	1968e	1967	1968e	1967	1968e
Production	935,000	980,000	. .	. .	. .	. .
Imports	208,000[3]	250,000	167,100	150,000	7,176	5,500
Consumption	1,042,000[3]	1,100,000[3]	153.457	160,000	20,062	14,500
Price per pound	na	na	6.0¢[1]	6.2¢[1]	$1.32	$1.32
Price per long ton[1]	$21-24	$20-21	na	na	na	na

Source: U.S. Bureau of Mines, Commodity Data Summaries, January 1969.

[1]f.o.b. Atlantic Seaboard. [2]Short tons of sponge metal. [3]Includes titanium slag from Canada.

eEstimated; . .Not available; na Not applicable.

TABLE 5

Consumption of Titanium Concentrates in the United States by Products, 1967
(short tons)

	Ilmenite[1]		Titania Slag		Rutile	
Products	Gross Weight	Estimated TiO_2 Content	Gross Weight	Estimated TiO_2 Content	Gross Weight	Estimated TiO_2 Content
Pigments	916,398	486,739	122,926	86,945	96,401	92,795
Titanium metal	–	–	–	–	2	2
Welding-rod coatings	2	–	3	–	21,190	20,139
Alloys and carbide	2,414	1,265	3	–	737	697
Ceramics	2	–	–	–	4	4
Fiberglass	–	–	–	–	2	2
Miscellaneous	394	232	–	–	35,129	33,527
Total	919,206	488,236	122,926	86,945	153,457	147,158

Source: U.S. Bureau of Mines, Minerals Yearbook 1967.

[1]Includes mixture containing rutile, leucoxene and ilmenite. [2]Included with miscellaneous to avoid disclosing confidential data. [3]Included with pigments. [4]Included with alloys and carbides to avoid disclosure.

– Nil.

SIERRA LEONE

The world's largest single rutile mining operation was prepared for production in 1967 by Sherbro Minerals Limited on large alluvial deposits in Sierra Leone. The cutting-head suction dredge and plant of Sherbro are reported to have a capacity of 100,000 tons of rutile concentrates a year. Sherbro Minerals is jointly owned by PPG Industries, Inc. and British Titan Products Company Limited.

TABLE 6

Australian Production of Ilmenite and Rutile, 1966-67
(long tons)

	1966		1967	
	Concentrate	TiO_2 Content	Concentrate	TiO_2 Content
Ilmenite				
Production	513,011	280,841	538,673	291,311
Exports*	356,462	196,954	384,300	217,239
Leucoxene				
Production	756	630	1,856	1,610
Rutile				
Production	243,858	235,274	274,963	264,126
Exports	231,289	223,166	258,791	248,694*

Source: Australian Mineral Industry, Quarterly Review, Vol. 20, No. 4, June 1968.
*Includes leucoxene.

TABLE 7

Non-Communist Production of Ilmenite Concentrates, 1967-68
(thousand short tons)

	1967	1968e
United States	935	980
Australia	600	650
Canada	602*	673*
Norway	408	400
Malaysia	140	. .
Finland	138	. .
Other countries	137	400
Total	2,960	3,103

Sources: For 1967, U.S. Bureau of Mines, Minerals Yearbook, 1967; for 1968, U.S. Bureau of Mines, Commodity Data Summaries, January 1969, and company reports.
*Titania slag containing 72% TiO_2.
eEstimated; . . Not available.

TABLE 8

Non-Communist Production of Rutile Concentrates, 1967-68
(short tons)

	1967	1968e
Australia	307,958	336,000
Sierra Leone	15,000	50,000
India	2,000	2,000
Brazil	400e	400
Total	325,358	388,400

Sources: For 1967, U.S. Bureau of Mines, Minerals Yearbook, 1967; for 1968, U.S. Bureau of Mines, Commodity Data Summaries, January 1969, and company reports.
eEstimated.

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 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.

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 non-communist countries.

Titanium dioxide pigment owes its whiteness to its high index of refraction which accounts for its opacity. 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

TABLE 9

Estimated TiO_2 Pigment Production Capacity
Annual Capacity by Countries, 1968

	Sulphate Process	Chloride Process		Sulphate Process
	(short tons)			(short tons)
United States	633,000	198,000	Netherlands	12,000
Canada	67,000	10,000	Norway	16,500
Britain	179,200	(partly)	Mexico	7,700
France	55,100	27,500	Argentina	4,400
West Germany	215,000	19,000	Brazil	4,400
Belgium	16,500		South Africa	14,000
Italy	54,000		India	16,500
Spain	10,500		Japan	109,100
Portugal	6,600		Australia	41,400
Finland	17,600			
			GRAND TOTAL 1,735,000	

Sources: Industrial Minerals, No. 4, January 1968 published by Metal Bulletin Ltd., London; Australian Mineral Industry, Vol. 19, No. 4, June 1967; Mining Engineering, February 1967.

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° Centigrade. 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 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.

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 1967, imported about 150,000 tons of rutile concentrates, 99 per cent from Australia.

Consumption of ilmenite is almost wholly confined to the sulphate process manufacture of TiO_2 pigments, which have 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 10

Canada, Consumption of Titanium Dioxide
and Titanium Dioxide Pigments
(short tons)

	1965	1966
Refined Titanium Dioxide		
Paint and varnish	22,884	24,235
Paper	3,804	4,073
Linoleum	1,570	2,104
Rubber	1,691	2,078
Miscellaneous non-metallic products	806	835
Synthetic textiles	68	–
Toilet preparations	27	33
Industrial chemicals	39	121
Other chemicals	601	821
Extended Titanium Dioxide Pigments		
Paint and varnish	8,193	9,131

Source: Dominion Bureau of Statistics, Ottawa.
– Nil.

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 58 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.

Titanium ingot production in the United States was 19,234 tons in 1967 compared with 25,960 tons in 1966. Titanium sponge, the intermediate product in titanium metal ingot production, is produced for domestic and export markets also by Japan, Britain and the USSR.

PRICES

Prices in the United States quoted in *Metals Week* of December 30, 1968 were:

	US Currency
Titanium ore	
f.o.b. cars Atlantic ports,	
Rutile, 96%, per short ton, delivered within 12 months	\$121 – \$125
Ilmenite, 54%, per long ton, shiploads	20 – 21
Slag, 70%, per long ton, f.o.b. shipping point	43
Titanium metal	
Sponge, per lb, f.o.b. mine or mill	
max. 115 Brinell, 99.3%, 500 lb	1.32
Japanese, British, 99.3%	1.20 – 1.25
Max. 90 Brinell, 99.9%, 25 lb	1.90
Max. 75 Brinell, 99.9%, 10 lb	4.00
Max. 60 Brinell, 99.9%, 2 lb	25.00
Mill products	
per lb, delivered, 4,000 lb. lots	
Billet, Ti – 6A1-4V (8" diameter, random lengths)	2.53
Bar, Ti – 6A1-4V (2" diameter)	3.63
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 of titanium dioxide in 1968 were:	
Anatase, dry milled, bags, car lots, delivered, East, per 100 pounds	22.50
Anatase, regular, bags, car lots, delivered, East, per 100 pounds	25.00
Rutile pigment, bags, car lots, delivered, East, per 100 pounds	27.50

TARIFFS

	British Preferential	Most Favoured Nation	General
CANADA			
Titanium ore	free	free	free
Titanium oxide and white pigments containing not less than 14% TiO_2 by weight	free	12½%	15%
Ferrotitanium	free	5%	5%
UNITED STATES			
Titanium ore (including ilmenite, ilmenite sand, rutile and rutile sand)		free	
Titanium metal, unwrought, waste and scrap (duty on waste and scrap suspended to June 30, 1969)			
On and after Jan. 1, 1968		19.5%	
On and after Jan. 1, 1969		19%	
Titanium metal, wrought		18%	

Ferrotitanium and ferrosilicon-titanium	
On and after Jan. 1, 1968	9%
On and after Jan. 1, 1969	8%
Titanium dioxide and titanium compounds	
On and after Jan. 1, 1968	13%
On and after Jan. 1, 1969	12%

Sources: The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa.

Tariff Schedules of the United States Annotated (1969) TC Publication 272.

Tungsten

G. P. WIGLE*

Canada's only tungsten producer, Canada Tungsten Mining Corporation Limited, completed a full year of operation in 1968 after rebuilding its crushing and concentrating plant which had been destroyed by fire in December 1966. The new plant came into service in November 1967 and in 1968 treated 116,558 tons of ore averaging 1.98 per cent tungsten trioxide and 0.32 per cent copper. Scheelite recovery was 77.74 per cent and production was 180,000 short-ton-units† of tungstic oxide (WO_3) (2,855,160 pounds contained tungsten) and 596,000 pounds of copper. The company's leach plant in North Vancouver upgraded flotation concentrates of scheelite ($CaWO_4$) from an average of 31 per cent WO_3 to 68 per cent WO_3 by acid dissolution of contained calcite. The open-pit mine and concentrator is in the Northwest Territories, near the Yukon border, about 135 miles north of Watson Lake. Ore reserves at December 31, 1968 were estimated at 813,893 tons averaging 1.61 per cent WO_3.

The Buchans Unit of American Smelting and Refining Company drove 3,300 feet of adit to develop and explore a tungsten deposit at Grey River on the south coast of Newfoundland.

Burnt Hill Tungsten & Metallurgical Limited prepared for shaft sinking and underground development on the company's tungsten property in York County, New Brunswick. The shaft is to be sunk to a depth of 260 feet and drifting undertaken on the 125 foot and 250 foot levels.

Consumption of tungsten in 1967 and 1968 was lower than the record high of 1966 but remained above the level of prior years. The price of tungsten in the United States continued at or near $43 a short-ton-unit of WO_3, c.i.f. U.S. ports, duty paid, at which basic price some 3.25 million pounds were sold from stockpile by the United States General Services Administration.

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 ($FeMnWO_4$) varies in composition with 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, hubnerite ($MnWO_4$). 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 waxlike 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 make up about 0.0069 per cent of the earth's crust which is near the relative abundance of 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.

*Mineral Resources Branch.

†A short-ton unit is 20 pounds of WO_3, and contains 15.862 pounds of W.

TABLE 1

Canada, Tungsten Production, Imports and Consumption, 1967-68

	1967		1968p	
	Pounds	$	Pounds	$
Production[1] (WO_3)	–	–	3,600,000	..
Imports				
Tungsten in ores and concentrates				
United States	141,500	352,000	63,300	145,000
South Korea	–	–	34,600	69,000
Britain	51,400	116,000	33,800	66,000
Other countries	40,700	52,000	–	–
Total	233,600	520,000	131,700	280,000
Ferrotungsten[2]				
Portugal	74,000	178,000	72,000	186,000
Britain	114,000	306,000	46,000	117,000
United States	4,000	16,000	–	–
Total	192,000	500,000	118,000	303,000
Consumption, W content				
Tungsten ore	405,758	..	..	..
Tungsten metal and metal powder	264,104	..	..	..
Tungsten wire	6,647	..	..	..
Other[3]	214,902	..	..	..
Total	891,411	..	..	..

Source: Dominion Bureau of Statistics.

[1]From company annual reports. [2]Gross weight. [3]Includes ferrotungsten, tungsten carbide powder.

pPreliminary; – Nil; .. Not available.

TABLE 2

Canada, Tungsten Production, Trade and Consumption, 1959-68
(pounds)

	Production[1]	Imports		Consumption
	WO_3 Content	Tungsten Ore[3]	Ferrotungsten[4]	W Content
1959	–	840,000	828,600	659,991
1960	–	1,156,900	980,700	947,222
1961	–	501,800	518,300	843,228
1962	3,580	2,854,300	285,600	1,039 628
1963	–	645,500	624,100	903,924
1964	–	389,800	172,000	740,410
1965	3,736,324	357,400	354,000	877,614
1966	4,260,440[2]	523,600	192,000	941,207
1967	–	233,600	192,000	891,411
1968p	3,600,000[2]	131,700	118,000	..

Source: Dominion Bureau of Statistics.

[1]Producers' shipments of scheelite (WO_3 content). [2]From company annual reports. [3]Prior to 1964 reported in gross weight, commencing in 1964, reported in W content. [4]Gross weight.

pPreliminary; .. Not available; – Nil.

Tungsten mineral occurrences are found 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. Scheelite, and less frequently wolframite, occurrences in contact metamorphic skarn zones are numerous in northern British Columbia, the Yukon and Northwest Territories. Wolframite has been found in stream gravels and in quartz veins in Yukon Territory and British Columbia. Scheelite is found in many parts of Canada in association with gold-bearing quartz veins but usually in minor amounts. Scheelite, wolframite, hubnerite and tungstite have been found in quartz veins, pegmatites and greisen in the Atlantic provinces.

WORLD PRODUCTION

World production of tungsten ores and concentrates in 1968 contained an estimated 65 million pounds of tungsten. Approximately 36 million pounds of the world total was produced in East Asian communist countries as outlined in Table 3. The USSR is second among world producers of tungsten; it is a major consumer and a net importer of tungsten with its additional supply coming from mainland China, the leading producer.

TABLE 3

World Production of Tungsten Ore and Concentrates, 1966-68
(thousand pounds of contained tungsten)

	1966	1967	1968
China	17,600	17,600	17,600
USSR	13,000	13,600	13,600
United States	8,482	8,649	7,700
North Korea[e]	4,720	4,720	4,800
South Korea	4,530	4,464	4,400
Canada	3,379[r]	–	2,855[r]
Bolivia	3,760	3,494	3,500
Australia	2,322	2,108	2,250
Portugal	2,096	2,428	2,450
Other countries	4,212	4,799	5,530
Total	64,101	61,862	64,685

Source: U.S. Bureau of Mines, Minerals Yearbook 1967; U.S. Bureau of Mines, Commodity Data Summaries, January 1968; and Company reports.

[e]Estimated; – Nil; [r]Revised.

Production of tungsten in the United States was an estimated 7.7 million pounds in 1968. The major United States producers are Union Carbide Corporation's Pine Creek mine near Bishop, California, and the Climax mine of Climax Molybdenum Company in Colorado.

CONSUMPTION AND USE

United States consumption of tungsten in 1968 was an estimated 12 million pounds. The major consumers are the producers of tungsten carbides and metal powders, and the steel producers.

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; as 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. Flame-plating 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 ball-point pens.

In high-temperature nonferrous and superalloy fields, where temperature resistance requirements are beyond the ability of highly alloyed 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.

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 per cent 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. Tungsten chemicals are used in textile dyes, paints, enamel and glass manufacture.

TABLE 4

Consumption of Tungsten in Canada, by Use, 1967
(pound of contained W)

Carbides	574,861
Alloy steels	276,065
Electrical and electronic	9,389
Other*	31,096
Total	891,411

Source: Compiled in Mineral Resources Branch from data supplied by Dominion Bureau of Statistics.

*Includes nonferrous alloys, chemicals and pigments.

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,* Crucible Steel of Canada Ltd., Sorel; Shawinigan Chemicals Limited, Montreal; *in Ontario,* Atlas Steels Division of Rio Algom Mines Limited, Welland; Canadian General Electric Company Limited, Toronto; A. C. Wickman, Limited, Toronto; Canadian Westinghouse Company 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 partially processed and semi-fabricated tungsten products.

PRICES

According to *Metals Week*, December 30, 1968, United States tungsten prices were as follows:

	$US
Tungsten ore:	
per short-ton unit of WO_3, 65% minimum WO_3,	
Wolfram	43.00
Scheelite	43.00
($7.14 duty per short ton unit of WO_3, or 45¢ per lb of W included)	
Tungsten metal	
per lb, delivered	
Carbon red, 98.8%, 1000 lb lots	2.75
Hydrogen red, 99.99%, depending on Fisher No., range	4.60–5.44
Typical Fisher No. 4.00	4.60
Ferrotungsten–per lb contained W	
delivered, regular	3.20–3.40
UCAR	3.71

TARIFFS

	British Preferential	Most Favoured Nation	General
CANADA			
Tungsten ores and concentrates	free	free	free
Tungsten oxide in powder or lumps or in briquettes made with binding material used in steel manufacture	free	free	5%
Tungsten carbide in metal tubes	free	free	free
Ferrotungsten	free	5%	5%
Tungsten rod and tungsten wire for use in Canadian manufactures	free	free	25%
Tungsten metal, in lumps, powder, ingots, blocks, or bars, and scrap of alloy metal, for use in alloying purposes	free	free	free

UNITED STATES

Tungsten ore

On and after Jan. 1, 1968 45¢ per lb on W content

On and after Jan. 1, 1969 40¢ per lb on W content

Tungsten metal

Unwrought, other than alloys, lumps, grains and powders

On and after Jan. 1, 1968
37¢ per lb on W content + 22.5%
On and after Jan. 1, 1969
33¢ per lb on W content + 20%

Ingots and shot
On and after Jan. 1, 1968 18.5%
On and after Jan. 1, 1969 16.5%

Other
On and after Jan. 1, 1968 22.5%
On and after Jan. 1, 1969 20%

Alloys
Containing by weight not over 50% W content
On and after Jan. 1, 1968
37.8¢ per lb on W content + 11%
On and after Jan. 1, 1969
33.5¢ per lb on W content + 10%

Sources: The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa.

Tariff Schedules of the United States Annotated (1969) TC Publication 272.

Containing by weight not over 50% W content
On and after Jan. 1, 1968 22.5%
" " " " ", 1969 20%

Waste and scrap
Containing by weight not over 50% W
On and after Jan. 1, 1968,
37.5¢ per lb on W content + 11%
On and after Jan. 1, 1969
33¢ per lb on W content + 10%
Containing by weight over 50% W content
On and after Jan. 1, 1968 18.5%
" " " " ", 1969 16.5%

Wrought
On and after Jan. 1, 1968 22.5%
" " " " ", 1969 20%

Uranium and Thorium

R.M. WILLIAMS*

URANIUM

The future of the uranium industry continued to brighten during 1968 as producers became increasingly aware of the magnitude of the potential fuel requirements of the world's nuclear power industry. As of January 1, 1969 there were some 12,000 electrical megawatts (MWe) of nuclear capacity in operation in the world. In addition, some 80,000 MWe was either under construction or on order, representing a total financial commitment by electrical utilities of more than $13,000 million. By 1980, it is expected that the non-communist world will have a total installed nuclear capacity in excess of 250,000 MWe, thus providing an annual market for uranium oxide concentrates (U_3O_8) valued at $1,200 million to $1,700 million (assuming a price of $8 a pound for U_3O_8). In anticipation of these markets, uranium exploration reached outstanding levels of activity and urgency in many parts of the world, particularly in the United States, Canada and Africa.

In Canada, one new uranium mine was opened and the development of two others proceeded on schedule. One past producer was reactivated and plans for the reactivation of others were announced. Although no significant long-term sales contracts were announced during 1968 by Canadian producers, negotiations proceeded with several overseas customers and contracts were expected in the near future. Prospects for additional domestic sales were also indicated when The Hydro-Electric Commission of Ontario (Ontario Hydro) announced in December that it will construct another nuclear power station having 3,000 MWe of capacity at Douglas Point, Ontario. Of particular significance to Canada's uranium production capabilities was the decision by Eldorado Nuclear Limited,** in early 1968, to proceed with the construction at its Port Hope, Ontario, refinery of facilities to produce uranium hexafluoride (UF_6). Thus, Canada's uranium industry is in the forefront of uranium developments; there is every indication that it will be capable of meeting a significant proportion of the expected heavy demand of the 1970's.

PRODUCTION

In 1968 four Canadian operations produced an estimated 4,100 tons of U_3O_8. Of this the companies shipped 3,700† tons valued at an estimated $45,482,000, the remaining production being kept in inventory. About seventy-five per cent of Canada's uranium production comes from three operations which produce from quartz-pebble conglomerates in the Elliot Lake area of Ontario. Denison Mines Limited operates the largest single mine in the area to supply ore to its mill that in late 1968 was operating at some two-thirds capacity. Rio Algom Mines Limited operated its Nordic mill at full capacity until mid-1968 when its output was replaced by the reactivated Quirke mill. Quirke was also run at full capacity and in late 1968 was being supplied with ore from three Rio Algom mines in the area. Stanrock Uranium Mines Limited, has not mined by conventional methods since October 1964 but continues to recover small quantities of uranium from its mine water. The fourth

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*Mineral Resources Branch.

**Name changed from Eldorado Mining and Refining Limited in June 1968.

†1 short ton U_3O_8 – 770 kilograms of uranium metal.

Canadian operation, Eldorado Nuclear Limited, produces from a pitchblende vein-type deposit in the Beaverlodge area of northern Saskatchewan. At year-end its mill was operating at 85 per cent capacity.

TABLE 1

Uranium Production in Canada, by Province 1967-68

	1967		1968p	
	Pounds	$	Pounds	$
Production (U_3O_8 shipments)				
Ontario	5,450,639	41,418,268	5,400,000	35,482,000
Saskatchewan	2,025,589	11,603,668	2,000,000	10,000,000
Total	7,476,228	53,021,936	7,400,000	45,482,000

Source: Dominion Bureau of Statistics.
pPreliminary.

TABLE 2

Uranium Production by Major Producing Countries, 1958-68
(short tons U_3O_8)

Year	Canada	United States	South Africa	Congo	Australia	France*	Non-communist World
1958	13,403 $279,538,471	12,570	6,245	2,300	700	755	36,250
1959	15,892 $331,143,043	16,420	6,445	2,300	1,100	1,065	43,350
1960	12,748 $269,938,192	17,760	6,409	1,200	1,300	1,379	41,130
1961	9,641 $195,691,624	17,399	5,468	–	1,400	2,141	36,300
1962	8,430 $158,183,669	17,010	5,024	–	1,300	2,603	34,500
1963	8,352 $136,909,119	14,218	4,532	–	1,200	2,692	31,025r
1964	7,285 $ 83,509,429	11,847	4,445	–	370r	2,746	26,782r
1965	4,443 $ 62,361,377	10,442	2,942	–	370	2,676	21,115r
1966	3,932 $ 54,334,787	9,587r	3,286	–	330	1,925r	19,164r
1967	3,738 $ 53,021,936	9,125	3,360	–	330	1,800e	18,553r
1968p	3,700 $ 45,482,000	12,600	3,800e	–	330	2,100	22,830

Sources: United States Bureau of Mines (USBM) Minerals Yearbooks; USBM Mineral Facts and Problems, 1965 Edition; USBM Commodity Data Summaries, January 1969; for South Africa, Department of Mines Quarterly Reviews; and for Canada, Dominion Bureau of Statistics, producers'shipments.

*Includes Gabon and Malagasy Republic.
pPreliminary; rRevised; eEstimated; – Nil.

Denison's long-range program of underground development continued throughout 1968, mining methods were altered to increase productivity, and new equipment was introduced to maximize efficiency. In addition, a major new conveyor system in the eastern portion of the mine was completed and put into operation and a large underground crusher was installed. These improvements make Denison capable of hoisting some 10,000 tons of ore a day, thus putting it in a position to handle its large ore reserves being developed to the east. The Can Met drift was completed in late 1968, and will be the main haulageway for exploiting these reserves. Denison's 6,000-ton-a-day mill operated at about 4,000 tons a day throughout most of 1968. The recovery of rare-earth concentrate* as a byproduct, which began in 1967, was discontinued temporarily in the latter part of 1968. Denison treated 1,316,000 tons of ore in 1968, with an average grade of 3.07 pounds of U_3O_8 a ton, to produce 3,843,000 pounds of U_3O_8.

Rio Algom's production during the first half of 1968 continued to come from its Nordic mine and 3,700-ton-a-day mill. The continued operation of the Nordic mine will necessitate the development of ore reserves to the north of the present workings, a project that will require some two to three years. Consequently, as announced in 1967, the Nordic operation was temporarily suspended in mid-July 1968 and, concurrently, production was resumed at the Quirke mine and mill, some 10 miles to the north. Rehabilitation of the Quirke facilities, idle since January 1961, was begun in early 1967; the milling capacity at Quirke was increased from 3,000 to 3,700 tons of ore a day. The company milled a total of 1,167,000 tons of ore in 1968 with an average recovered grade of 1.96 pounds of U_3O_8 a ton; average recovery was 93.3 per cent. A total of 2,293,000 pounds of U_3O_8 was produced, including 96,000 pounds of U_3O_8 from underground leaching at Nordic and old Quirke.

At the same time as the temporary phase-out of the Nordic operation, Rio Algom's nuclear products department suspended production of thorium concentrates; recovery of rare earth concentrates had been suspended in late 1967.

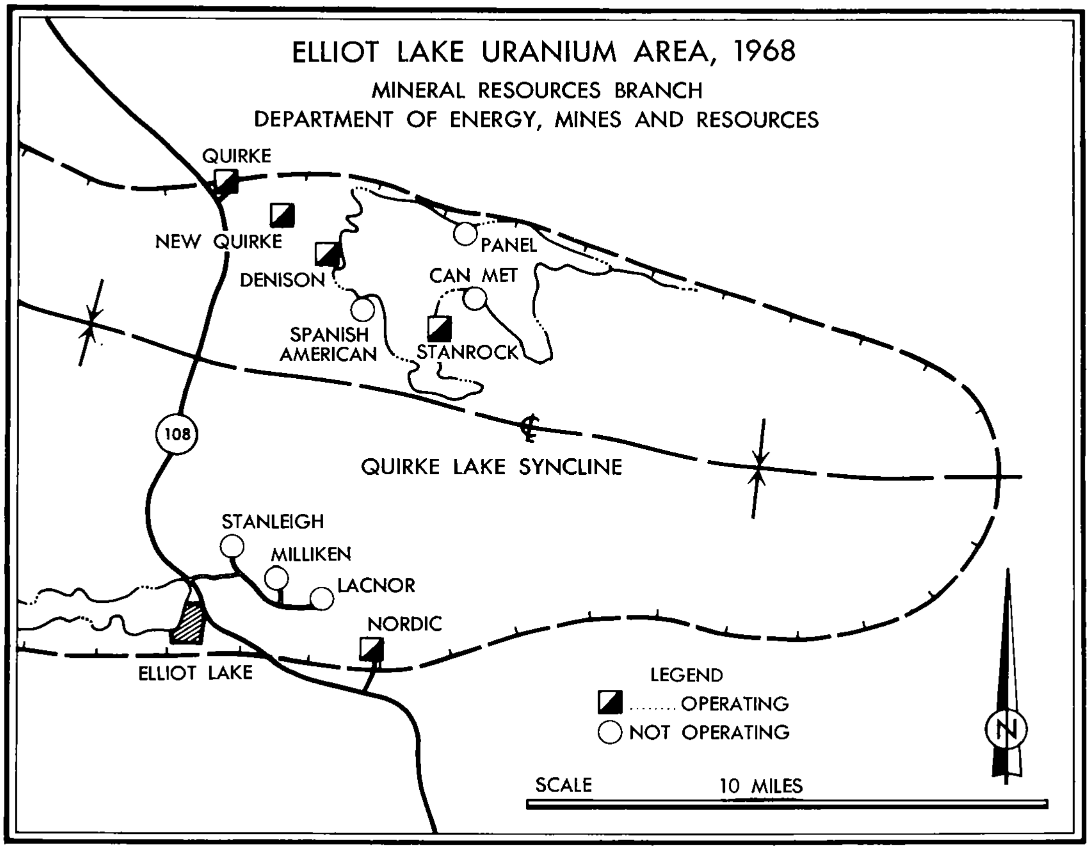
In October 1968, Rio Algom officially opened its New Quirke mine about two miles east of old Quirke, also on the north limb of the Quirke Lake syncline. The New Quirke shaft had been collared in 1960, but construction of the surface facilities was suspended due to the rapid decline in uranium demand at that time. Preparation of the surface plant, one of the most modern in Canada, was resumed in late 1966 and shaft sinking, to a depth of 2,263 feet, was begun in January 1967. The mine was providing some 300 tons of ore a day to the Quirke mill by November 1968, and its output will be increased to 2,200 tons a day during 1969, to 3,200 tons in 1970, and finally to 5,200 tons a day in 1971. In that year production from New Quirke will provide all feed to the mill because the reserves at old Quirke will have, by then, been exhausted. Ore will be transported from New Quirke to the mill by a 48-inch gauge semi-automatic electric surface railroad. The total cost of reactivating the Quirke facilities and developing the New Quirke mine has been estimated at $14.5 million.

Production of uranium from Stanrock's underground leaching operation, that had declined appreciably in 1967, was stabilized at about 6,000 pounds of U_3O_8 a month during the latter part of 1968. Cyclical washing of stopes, as practiced since 1965, was discontinued in August 1968 and recovery of uranium in the water from the flooded portions of the mine was begun. This second phase of the leaching program really began in mid-1967 when barren mill effluent was fed underground and isolated in western areas of the mine by a concrete bulkhead. Three additional bulkheads were under construction at the end of 1968 that will permit the flooding of additional areas which will, in turn, be used to feed the mill. It is expected that production by this method from the old mine workings can be continued for some time. Total 1968 production of U_3O_8 had a sales value of $512,598. Recovery of rare-earth concentrates was suspended in late 1967 because of poor market conditions.

Eldorado's 2,000-ton-a-day mill operated at the rate of 1,700 tons a day during 1968, which is about the limit of its leaching capacity without rehabilitating its autoclave circuit. A total of 625,615 tons of ore were treated to produce 2,001,648 pounds of U_3O_8; average recovery was 3.19 pounds of U_3O_8 a ton, the lowest in the history of the mine. Operating costs a pound U_3O_8 produced were 7.5 per cent higher than in 1967, although the cost a ton mined was 3.7 per cent lower than in 1967. The higher cost a pound was attributed in part to the lower grade of ore treated and in part to the continued high labour turnover.

Eldorado's exploration-development work was maintained at a high level and results of drilling downward extensions of the Fay system were very encouraging. To develop this ore, long-range plans are being made that will involve the sinking of an internal production shaft east of the Fay shaft. The internal shaft will be collared at the 24th level (3,475 feet) and sunk, initially, some 1,500 feet. Ultimately, the shaft may be sunk a further 3,000 feet to a total depth from surface of nearly 8,000 feet. Facilities for the handling of custom ore have been designed and will be installed when market conditions and uranium developments in the area warrant. The cost of the latter facilities was estimated at $500,000. Eldorado also completed a million dollar employee-housing project in Uranium City in 1968 and planned to spend a similar amount in 1969.

*See 1968 Mineral Review No. 39, Rare Earths, by W.H. Jackson.



DEVELOPMENT

Rio Algom's announcement, in October 1968, that it would spend about $26 million on the reactivation of additional production facilities in the Elliot Lake area was, perhaps, the most significant development of the year. The project will take some four or five years, if markets develop as expected, and will be carried out in two phases. The first phase, begun in November 1968, involves the rehabilitation of shafts at the Lacnor mine, development of ore reserves that are mid-way between the Lacnor and Nordic properties, and the subsequent reactivation of the Nordic mill. Requisite in the project is the driving of a major haulageway some 4,000 feet from the northern limits of the Nordic orebody to the Lacnor mine. Ore will be hoisted in the Lacnor to this common haulage level, where it will be transported to Nordic for transfer to the mill. It is expected that this project will cost about $12 million, and that the Nordic mill will be reactivated in late 1971.

Subsequently, Rio Algom will reactivate the Panel mine and 3,000-ton-a-day mill, which has been idle since July 1961, at an estimated cost of $14 million. Panel is about five miles east of Quirke, also on the north limb of the Quirke Lake syncline. It is expected that the Panel orebody will be capable of providing up to 1,500 tons of ore a day to the mill and the remainder will be supplied by the 5,200-ton-a-day New Quirke mine, which will have reached full capacity by that time.

Development of the Agnew Lake Mines Limited property, in Hyman Township about 30 miles west of Sudbury, continued on schedule. Construction of the mine plant and other surface facilities, which began in late 1967, is now complete. A seven-mile, paved access road and a power line have also been constructed. Shaft sinking to an initial depth of 3,000 feet began in July 1968, reached 1,400 feet at year-end, and is expected to be completed in late 1969. Lateral development will be carried out in conjunction with shaft sinking and is scheduled to begin in March 1969.

The design of the 3,000-ton-a-day mill is well under way but construction will not likely begin until after a contract is negotiated. It was estimated that the total cost of bringing the mine into production will approach $35 million. It is being financed by Kerr Addison Mines Limited (80 per cent), Quebec Mattagami Minerals Limited (10 per cent), and Anglo American Corporation of Canada Limited (10 per cent).

An underground development program continued throughout 1968 at Consolidated Canadian Faraday Limited's mine near Bancroft, Ontario. The program is being carried out under an option agreement with Federal Resources Corporation of Salt Lake City, Utah, which has formed a subsidiary, Can-Fed Resources Corporation, to manage the project. Federal, a major uranium producer in the Gas Hills area of Wyoming, will acquire a 51 per cent interest in the mine by financing its return to production. Drilling to date has been successful in proving up those reserves which had been listed as probable when the operation closed in 1964 as well as in opening up significant potential reserves on almost all levels of the mine. It is estimated that the mill could be brought back into operation, probably at the rate of 1,000 to 1,250 tons a day, in about a year at a cost of about three million dollars.

The development of Eldorado's Hab mine, some 7 miles northeast of the Beaverlodge complex, proceeded on schedule. Shaft sinking to a depth of 735 feet was completed and cross-cutting began in October to reach the ore zones located approximately 1,000 feet on either side of the shaft. Development will be on four levels and it was estimated that the ore could be reached by mid-1969. The operation was designed to produce at a rate of 250 tons a day with the ore being trucked to the Eldorado mill. Total cost of the development was estimated at $3.2 million.

EXPLORATION

Uranium exploration activity in Canada continued at a rapid pace throughout 1968 with interest being shown in all of the areas of known uranium occurrences as well as in several new areas not previously investigated. Activity appears to have exceeded that reached in the peak years of the early 1950's. Unfortunately, few quantitative measurements of the activity in terms of claims staked, footage drilled or exploration dollars expended were readily available at year-end to illustrate the trend. However, one private survey, conducted by D.S. Robertson and Associates, estimated that about eight million dollars was spent on uranium exploration in Canada in 1968 of which three million dollars was in the Elliot Lake area of Ontario. After a period of some 10 years when only a few exploration permits were issued by the Atomic Energy Control Board (AECB) some 120 permits were issued during 1967 and 1968 to companies engaged in examination of uranium prospects across Canada.

The stage was set in the Elliot Lake area for a full-scale, organized, staking rush when the Ontario provincial government announced in late January that 100,000 acres of withdrawn land would be reopened for staking at noon on February 19, 1968. The land had been withdrawn in 1961 pending studies for its use as a provincial park; about 7,000 acres were retained for this purpose. Of particular interest was the southern part of the area, which straddled the north limb of the famous Quirke Lake syncline just west of Rio Algom's Quirke property. It is estimated that at least 1,000 persons took part in the rush and that over 2,500 claims were staked in less than two weeks. Drilling activity was again heavy in the Elliot Lake area and several companies, notably Kerr-McGee Corporation, were engaged in drilling to depths of 4,000 and 5,000 feet within the Quirke Lake syncline. Also of interest was the acquisition of provincial exploration permits covering large offshore areas in the North Channel of Lake Huron by Texas Gulf Sulphur Company, Aggressive Mining Limited and United Nuclear Mines (Canada) Limited.

The entire geological belt from Sault Ste. Marie to Sudbury as well as areas north of Sudbury, which contain the favourable Huronion sediments including Mississagi quartzites and quartz-pebble conglomerates, continued to be the object of intense interest. In addition, various pegmatitic uranium occurrences in Bancroft, Haliburton and adjacent areas of southeastern Ontario were being investigated. At least two small hydrothermal uranium occurrences were also being investigated, one located some 65 miles north of Thessalon and another some 80 miles northeast of Sioux Lookout.

In Quebec one of the more active areas during 1968 was the Lac Forestier-Ste-Anne-du-Lac area, a north-south trending belt about 5 to 8 miles wide and 35 miles long, located northeast of Mont Laurier. Numerous companies are involved, notably Canadian Johns-Manville Company, Limited which is investigating sill-like pegmatitic bodies associated with the Mekoos Intrusive in Leman Township in the southern part of the belt. Interest in the pegmatitic uranium occurrences of the Johan Beetz area, some 440 miles downstream from Quebec City on the north shore of the St. Lawrence River, declined during 1968 since results from the previous season were not encouraging. However, the pegmatites in the Ste. Simeon area, about 120 miles downstream from Quebec City, also on the north shore, and those in the Huddersfield Township area some 90 miles north of Ottawa continued to be investigated.

The Mistassini area, about 420 miles north of Montreal, continued to be the scene of considerable activity. Several companies were engaged in investigations of the basin of the Papaskwasati Formation which contains quartz-pebble conglomerates not unlike those in the Gowganda Formation at Elliot Lake. Similar interest was maintained in the Otish Mountains area, 100 miles northeast of Lake Mistassini. Another sedimentary area under investigation was that west of the Labrador Trough near Fort McKenzie where Denison and others have acquired extensive acreage.

In northern Saskatchewan, the Beaverlodge area continued to be the centre of activity. Most exploration was within a radius of 20 miles of Uranium City where companies were examining structural features favourable for pitchblende vein-type occurrences. Land acquisition over the past two years has spread so that the entire area, from Kisiwak Lake on the east to within a few miles of the Alberta border on the west and from Lake Athabasca on the south to the Tazin River on the north, has been tied up by claims, claim blocks and exploration permits. A considerable amount of surface drilling was completed but no discoveries of economic significance were reported. Uranium-bearing pegmatites in the Black Lake area, east of Lake Athabasca and in the Lac La Ronge area of central Saskatchewan were also being investigated. Little new activity was reported in 1968 in connection with the uranium-bearing lignite coal prospects in southern Saskatchewan.

What may well prove to be a major new area of uranium exploration is the basin of the Athabasca Formation which is bounded on the north by Lake Athabasca and on the southeast by the Wollaston Lake structural trend. The basin covers an area about 250 miles by 140 miles and contains an undetermined thickness of relatively flat-lying sandstones with minor shales and conglomerates thought to be Middle Proterozoic in age. Both the sandstones and the Wollaston Lake structural break are believed to be favourable for uranium occurrences. In December 1968, Gulf Minerals Company announced some very promising results of drilling in the Wollaston Lake area, precipitating a land acquisition rush which resulted in the issuing of exploration permits covering several million acres.

Activity was also evident in other regions of Canada notably in the Northwest Territories, northeast Alberta and Manitoba along the edge of the Precambrian Shield, and in several areas of British Columbia. Of particular note was Denison's agreement with nine Japanese electrical utilities covering joint uranium exploration ventures in Colorado and British Columbia. Subsequently, Denison made an agreement with Consolidated Rexspar Minerals & Chemicals Limited covering exploration of Rexspar's British Columbia properties, including its Birch Island uranium prospect.

While several foreign companies were participating in uranium exploration in Canada the most evident were Japanese and United States interests. For example, Kerr-McGee has embarked on a three-year joint exploration program with 15 Japanese firms on its large Elliot Lake holdings. At least seven companies which are major uranium producers in the United States have entered the Canadian scene, the most recent being Petrotomics Co. and United Nuclear Corporation. Denison, Rio Algom and Kerr Addison, on the other hand, have become active in the western United States and Rio Algom announced that it will develop its uranium deposit in the Lisbon Valley area of Utah. Almost every major oil company is now active in uranium exploration in the western United States and many of them, through Canadian subsidiaries, in various parts of Canada.

In July 1968 the Canadian government removed a restriction barring the Crown-owned company, Eldorado Nuclear Limited, from conducting off-property mineral exploration.

REFINING

Eldorado Nuclear Limited is Canada's only producer of refined uranium products, with its refinery at Port Hope, Ontario. Until early 1967 the bulk of Eldorado's refinery operation was connected with the conversion of mine concentrates to orange oxide (UO_3). Substantial quantities of uranium metal and natural ceramic UO_2 powder, as well as smaller quantities of enriched and depleted UO_2 powders and various uranium alloys, such as uranium carbide and uranium silicide, have also been produced both for the domestic and export markets.

In May 1968, Eldorado decided to proceed with its plan to expand its refinery to produce uranium hexafluoride (UF_6), which is used as feed material for the gaseous diffusion enrichment process. Construction of the facility has begun and the expansion is expected to cost an estimated $10.4 million. Production will begin in 1970 at the rate of 2,500 tons of UF_6 a year with provision being made for expansion to 5,000 tons of UF_6 a year at a later date. At the present time there is only one such facility in North America.

The refinery's solvent extraction circuit was shut down in mid-November so that efforts could be concentrated on the installation of the zirconium* and UF_6 circuits. However, enough refined uranium diuranate was stockpiled to permit the continued production of natural ceramic UO_2 powder until mid-1970. Production of this material increased by 250 per cent in 1968, and shipments were three times those of 1967. In this regard a continuous rotary reduction furnace was installed late in 1968.

*See 1968 Mineral Review No. 56, Zirconium, by G.P. Wigle.

SALES

During 1968, Rio Algom continued to make deliveries at the rate of 1,200 tons of U_3O_8 a year to the United Kingdom Atomic Energy Authority (UKAEA) under 'master' contracts made in the 1950's. Rio Algom is the only company still delivering under these contracts and its contract allotment will be completed in October 1971. All four Canadian producers are in a position to deliver to the Canadian government stockpile at a base price of $4.90 a pound U_3O_8 until June 30, 1970, and have negotiated permissive annual delivery rates for the period. However, only 38 per cent of the permissible quantity was delivered during 1968, largely due to economic considerations.

Several commercial sales contracts have been negotiated by Canadian producers since 1966, for a total commitment of about 37,000 tons of U_3O_8. Of this total, some 29,000 tons is destined for export markets in Japan, Britain and West Germany (Table 4). Prices under these sales contracts were not disclosed; allowances were made in the contracts, however, for adjustments to cover increased costs of labour and supplies, and in some cases provisions were included for advanced payments. Some deliveries were made in 1968 to West Germany and to Ontario Hydro. In addition, some 3,300 tons of U_3O_8 remained to be delivered to Britain under the old 'master' contracts at year-end.

As noted earlier, Eldorado will be in a position, beginning in 1970, to supply uranium in the form of UF_6. In this regard the company renegotiated two large contracts for the sale of U_3O_8, which it signed in 1967, for conversion to UF_6. In addition, two small contracts for the sale of uranium as UF_6 were signed by the company during 1968. At year-end discussions were in progress with other Canadian uranium producers relative to Eldorado's UF_6 conversion service.

Several provisional-type uranium supply arrangements have been made in the form of exploration and development agreements. For example, Denison's agreement with nine Japanese utilities for exploration in British Columbia and Colorado gives the Japanese first-call on some 10,000 tons of U_3O_8, and Kerr-McGee's agreement with another Japanese syndicate gives the Japanese first-call on up to 50 per cent of any future production. Similar agreements have been made between other Canadian operators and some West German firms.

Although Eldorado Nuclear Limited handled all marketing of Canadian uranium in the past, producers have been at liberty to negotiate their own sales contracts consistent with the government's policy on peaceful uses first announced in 1958. This policy was reaffirmed in June 1965 on the occasion of the announcement of the second government stockpile program.

TABLE 3

Exports of Uranium Concentrates from Canada, 1958-68 (thousands of dollars)

Year	United States	Britain	West Germany	Japan	Switzerland	India	Others	Total
1958	262,675	13,503	314	14	–	–	–	276,506
1959	278,913	32,603	129	107	122	20	10	311,904
1960	236,594	25,905	294	147	1	570	30*	263,541
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**	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
1968p	3	26,064	–	–	–	–	–	26,067
Total	1,262,563	297,390	1,615	537	123	590	53	1,562,871

Source: Dominion Bureau of Statistics, exports of radioactive ores and concentrates that cleared customs.
*Includes Sweden ($27,720);
**Brazil.
pPreliminary; – Nil.

TABLE 4

Major Canadian Uranium Sales, Announced Since 1966

Producer	Customer	Country	Total Quantity (short tons U_3O_8)	Delivery Period
Denison Mines Ltd.	Tokyo Electric, Kansai Electric and six others	Japan	10,500	1969 to 1978
Denison Mines Ltd.	Urangesellschaft M.B.H.	West Germany	400	1968
Eldorado Nuclear Ltd.	Tokyo Electric	Japan	500	1969 to 1973
Eldorado Nuclear Ltd.	Kernkraftwerk Obrigheim	West Germany	1,000	1969 to 1979
Eldorado Nuclear Ltd.	Ontario Hydro	Canada	1,300	1968 to 1977
Eldorado Nuclear Ltd.	Unnamed utility	West Germany	N/R	Prior to 1975
Eldorado Nuclear Ltd.	Unnamed utility	Sweden	N/R	Two-year period
Rio Algom Mines Ltd.	UKAEA	Britain	11,500	1973 to 1980
Rio Algom Mines Ltd.	UKAEA	Britain	3,300[1]	1969 to 1971
Rio Algom Mines Ltd.	Ontario Hydro	Canada	6,300	1970 to 1983
Rio Algom Mines Ltd.	Tokyo Electric, Kansai Electric and six others	Japan	5,000	1969 to 1978
Rio Algom Mines Ltd.	Canadian Westinghouse	Canada	93	1969 to 1970
Stanrock Uranium Mines Limited	Unnamed reactor manufacturer	United States	N/R	N/R
		Total	40,000	short tons U_3O_8 approx.

[1]Remaining to be delivered to UKAEA under old 'master' contracts at rate of 1,200 tons a year.
N/R – Not reported.

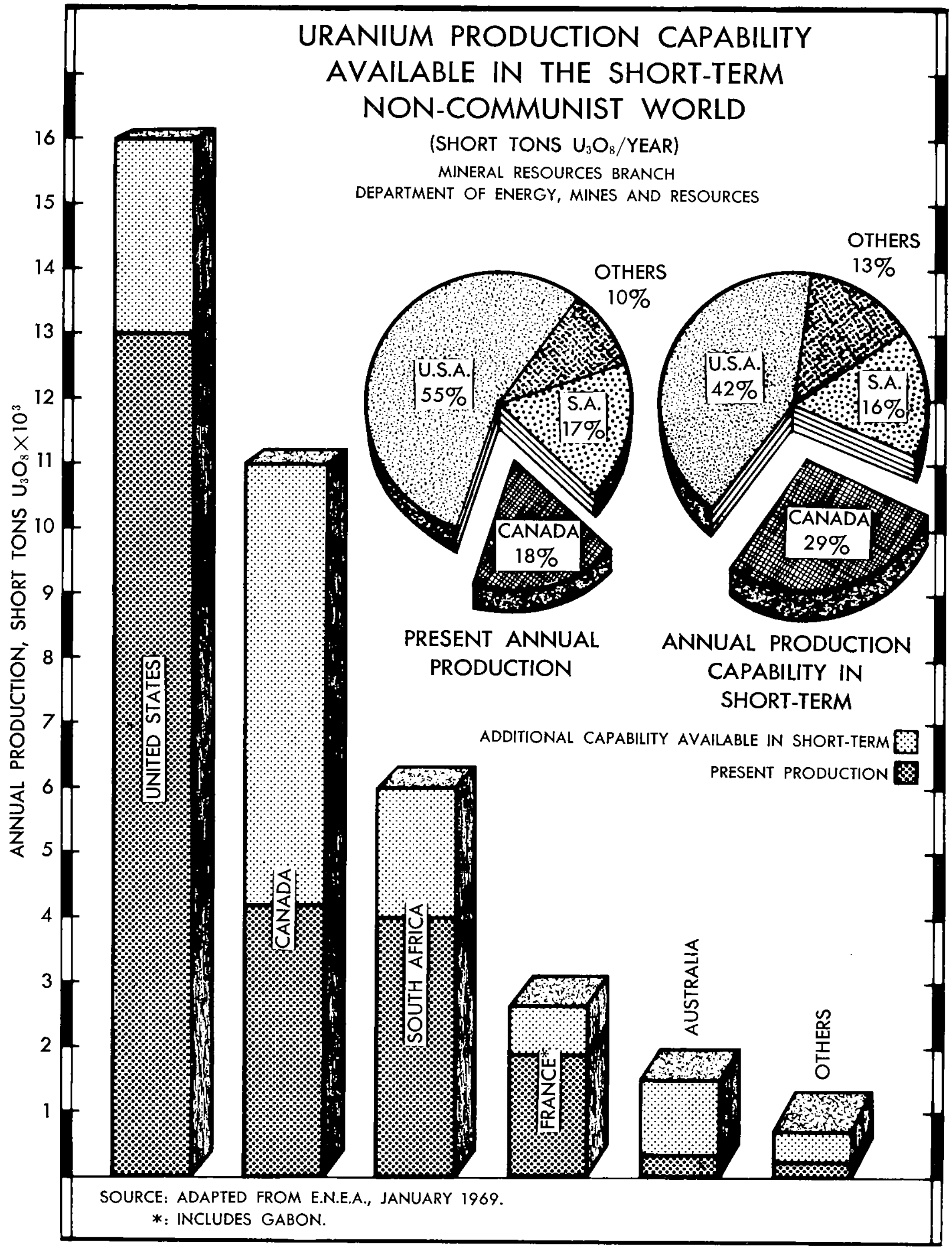
With the exception of Eldorado's two small sales of UF_6 no significant uranium sales contracts were announced during 1968. There were indications, however, that several contracts were under negotiation. Japan, Britain and West Germany will likely make further commitments and France, Italy, Sweden and Switzerland were among those named as potential customers. Further, the United States Atomic Energy Commission (USAEC) indicated, in September 1968, that it will likely remove the restriction on the enrichment of foreign uranium intended for domestic use by July 1, 1973 or possibly earlier. This would open the potentially large United States market to Canadian producers.

NUCLEAR DEVELOPMENTS

In June 1968, Ontario Hydro announced plans for the construction of a four-unit, 3,000 net electrical megawatt (MWe) nuclear power station at a site to be determined by year-end. In December, it was confirmed that the four 750-MWe units would be constructed at an estimated cost of $760 million on a site adjoining the 208-MWe Douglas Point Generating Station on the east shore of Lake Huron near Kincardine, Ontario. The latter has been in operation since early 1967. Construction of the new station, to be named the Bruce Generating Station, will begin in 1969 and the first unit is scheduled for completion in 1975.

The construction schedule at Ontario Hydro's four-unit, 2032-MWe Pickering Generating Station, at Pickering, Ontario, was revised early in 1968 due to various delays. The first unit is now expected to be in operation in October 1971 and the second unit in March 1972. The third and fourth units are scheduled for 1972 and 1973. Construction at Hydro Quebec's 250-MWe nuclear power plant at Gentilly, Quebec proceeded on schedule.

The 22-MWe Nuclear Power Demonstration (NPD) Station at Rolphton, Ontario was converted in 1968 from a pressurized-heavy-water (PHW) to a boiling-heavy-water (BHW) cooling system as part of a development program for future plants. Including the new 4-unit Bruce Station, there are at present seven nuclear power stations (14 reactors) of the Canadian design (natural uranium-fuelled and heavy water-moderated) either in operation, under construction or committed, representing a total capacity of some 6,040 MWe. All except the Gentilly station are designed to use a PHW cooling system; the latter uses a boiling-light-water cooling system.


URANIUM PRODUCTION CAPABILITY
AVAILABLE IN THE SHORT-TERM
NON-COMMUNIST WORLD
(SHORT TONS U_3O_8/YEAR)
MINERAL RESOURCES BRANCH
DEPARTMENT OF ENERGY, MINES AND RESOURCES
ANNUAL PRODUCTION, SHORT TONS $U_3O_8 \times 10^3$
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
UNITED STATES
CANADA
SOUTH AFRICA
FRANCE*
AUSTRALIA
OTHERS
OTHERS 10%
U.S.A. 55%
S.A. 17%
CANADA 18%
PRESENT ANNUAL PRODUCTION
OTHERS 13%
U.S.A. 42%
S.A. 16%
CANADA 29%
ANNUAL PRODUCTION CAPABILITY IN SHORT-TERM
ADDITIONAL CAPABILITY AVAILABLE IN SHORT-TERM
PRESENT PRODUCTION
SOURCE: ADAPTED FROM E.N.E.A., JANUARY 1969.
*: INCLUDES GABON.

In early 1968, an agreement was reached whereby Canadian General Electric Company Limited (CGE) and Atomic Energy of Canada Limited (AECL) would merge their nuclear power system design and engineering groups, under the direction of AECL. The object of the agreement, which will be for a five-year period, is to consolidate and streamline nuclear design and engineering capability in Canada. A further aim is to strengthen Canada's position in the competition for overseas sales of nuclear power systems. The move followed CGE's failure, in early 1968, in the bidding to supply a 350-MWe reactor to Argentina. The new AECL-CGE team had submitted a bid to Romania for the supply of a 300-MWe and a 600-MWe reactor at year-end.

In late 1968, Canada negotiated the sale of plutonium worth $1.5 million, to the Commissariat a l'Energie Atomique of France for use in the CEA's breeder reactor development program. The plutonium will be extracted at Euratom's fuel reprocessing facility in Belgium from irradiated fuel obtained from NDP and Douglas Point. The sale is governed by the application of Euratom safeguards.

At year-end, it was announced that AECL would build a heavy water (D_2O) production plant adjacent to the Douglas Point Generating Station. The plant will cost an estimated $65 million and its capacity will be 400 tons of D_2O a year initially, with provision for this to be doubled. The location was chosen to utilize steam from the Douglas Point plant. One other D_2O plant is under construction in Canada, that of CGE at Point Tupper, Nova Scotia. The Deuterium of Canada Limited plant at Glace Bay, Nova Scotia continued to experience difficulties. Both plants have a design capacity of 400 tons of D_2O a year.

OUTLOOK

The future of uranium in the next 20 or 30 years lies almost exclusively in its use as a nuclear fuel. Although forecasts of nuclear power capacity and related uranium requirements have been revised upward several times since 1962, estimates changed little throughout 1968. The decline in rate of nuclear plant orders, particularly in the United States, was attributable primarily to the cyclical nature of utility plant orders and the consequent levelling off of sales in line with power requirements.

The most recent forecast of uranium requirements in the non-communist world* was published in January 1969 by the European Nuclear Energy Agency (ENEA). This study predicts that the annual demand for uranium as a nuclear fuel will rise from 12,500 tons of U_3O_8 in 1968 to between 73,000 and 106,000 tons of U_3O_8 in 1980. At these levels of annual uranium production the cumulative requirement for uranium as a nuclear fuel to 1980 will be between 563,000 and 739,200 tons of U_3O_8. The predictions for the early 1970's are on a fairly firm basis since most of the nuclear capacity expected during this period is already under construction or on order. Beyond 1980 projections are fraught with uncertainties largely due to changing reactor technology after that time. However, non-communist world requirements will likely exceed 100,000 tons and perhaps reach 200,000 tons of U_3O_8 a year by the year 2000; on this basis, cumulative requirements to the year 2000 will be an estimated 2 million to 4 million tons of U_3O_8.

In 1968 the non-communist world produced about 23,000 tons of U_3O_8 (Table 2), somewhat below its estimated capacity. The short-term annual production capability of the industry was estimated by the ENEA in January 1969 at 38,000 tons of U_3O_8, attainable within about three years from facilities already installed, capable of reactivation or under construction. Capacity beyond the 38,000-ton-a-year level must be provided by new mines which in turn must be supported largely by reserves yet to be developed. According to the ENEA study an annual demand level of 38,000 tons of U_3O_8 a year will be reached by 1973 or 1974, after which new production capacity will be required. The need for new capacity could be delayed temporarily, however, by the release of uranium stockpiles held by various governments. In view of the lead-time required to construct new production facilities, it is apparent that plans should now be under way to provide the required additional capacity.

The magnitude of the challenge which the uranium industry must face during the next decade may be better appreciated by a review of the required investment. Based on the ENEA's median forecast of non-communist world annual uranium requirements in 1980, it is apparent that new low-cost reserves containing at least 1,000,000 tons of U_3O_8 must be outlined before 1980, if production levels expected by that time are to be adequately supported. Based on historical exploration costs, this represents an exploration expenditure of at least $1,000 million. Again based on historical figures the capital investment required to provide the production facilities expected by 1980 will likely be in the order of $2,000 to $2,500 million.

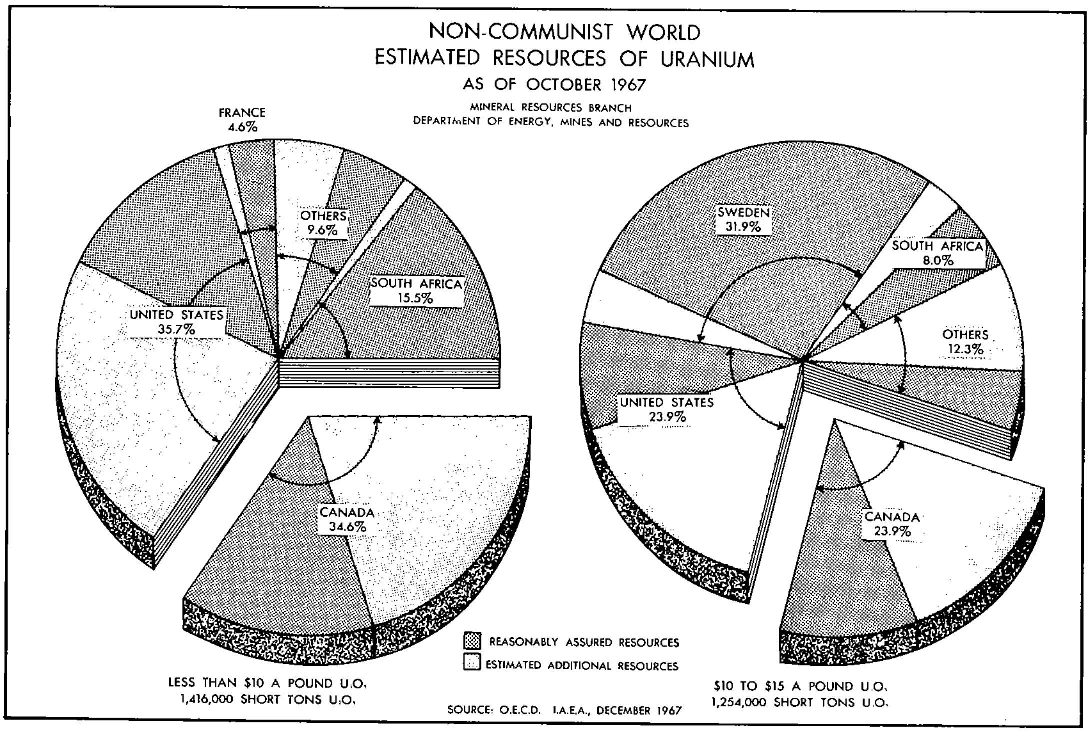
Although uranium exploration has become increasingly active during the past two or three years there was little evidence at year-end of discoveries that may lead to major increases in reserves. Clearly, the industry is entering a critical period. Significant discoveries of uranium are required and programs to generate additional production capability should soon be initiated. The possibility of a shortage of production capacity is compounded by the fact that,

*All countries except the USSR, Eastern Europe and China.

in some cases, plans for the expansion and reactivation of present facilities have been postponed due to the difficulty of raising capital without firm sales contracts.

Despite these uncertainties, the outlook for Canada's uranium industry is most promising. Of the 38,000-ton-a-year U_3O_8 non-communist world production capability, available in the short-term, some 98 per cent is in the United States, Canada, South Africa, France and Australia. The bulk of United States production, which accounts for some 42 per cent of this capability, will be committed largely to the United States market. Similarly, the output from metropolitan France and French speaking Africa will be committed largely to the French nuclear power program. Consequently, Canada, South Africa and Australia will have to provide most of the balance of the near-term non-communist world uranium supplies. Canada, with a short-term production capability of 11,000 tons of U_3O_8 a year is in a position to supply almost 60 per cent of this market.

In the longer term, the prospects for discovering additional uranium resources in Canada are good, as there are a good many geologically favourable areas, many of which have received only cursory examination. The expertise of Canada's mining industry is widely acknowledged and, given timely discoveries and reasonable prices, it will unquestionably be in a position to supply a major portion of the growing world market for uranium.



THORIUM

The nuclear products department of Rio Algom Mines Limited continued to be Canada's only producer of thorium concentrates in 1968. Produced as a byproduct of uranium* the operation was located at Rio Algom's Nordic mill in Elliot Lake, Ontario and had a capacity of 150 to 200 tons of thorium concentrates a year. As noted earlier, operations at the Nordic mine and mill were temporarily suspended in July 1968, and replaced by the reactivated Quirke mine and mill. Due to poor market conditions for thorium it was decided that a transfer of the thorium recovery circuit from Nordic to Quirke was not justified at that time. Shipments of thorium concentrate continued to be made however, from the company's inventory; the concentrate was a thorium sulphate ('thorium cake') and graded from 35 to 40 per cent thorium oxide (ThO_2).**

Essentially all 1968 production was shipped to Thorium Ltd., in Britain. However, small quantities of thorium cake were transferred, as required to the nuclear products department's Quirke refinery, where it was refined to metallurgical-grade thorium oxide (99.8 per cent + ThO_2) and shipped to Dominion Magnesium Limited, Haley, Ontario. At Haley, Dominion Magnesium produces sintered pellets of pure (98 per cent) thorium and thorium powder (99.5 per cent). Although the plant has a capacity of 200,000 pounds of thorium metal a year, production in 1968 was only 1,048 pounds compared with 835 pounds in 1967.

Prices† for thorium products in the United States, as quoted periodically in *Metals Week,* and the *American Metal Market*, were fairly steady during 1968. Thorium metal, pellets and powder were priced at $15.00 a pound, thorium nitrate at $2.25 to $3.50 a pound contained ThO_2 and high-purity thorium oxide at $12.30 a pound. Thorium-magnesium hardener (30-40 per cent Th) was quoted at $11.50 to $12.00 a pound of contained thorium plus the market value of the contained magnesium (35.25 cents a pound); on this basis 40 per cent thorium hardener costs about $4.82 a pound.

TABLE 5

Thorium Production in Canada, by Province, 1967-68

	1967		1968P	
	Pounds**	$	Pounds	$
Production				
(shipments of THO_2 concentrate)				
Ontario	117,383	214,597	139,191	269,128

Source: Dominion Bureau of Statistics.
PPreliminary.

USES

The use of thorium nitrate as an essential ingredient in the manufacture of gas lamp mantles began from 1890 to 1911, and continues to account for about 50 per cent of the total consumption of thorium. Because of its great tensile strength at high temperatures (730°F) thorium is alloyed with magnesium for use in the skin and structural components of supersonic aircraft. Nickel-thorium alloys have proved to have great strength and resistance to corrosion at temperatures as high as 2400°F; similar properties have been demonstrated in tungsten-thorium alloys. Thorium is also used as a deoxidant in the production of molybdenum and its alloys, as a catalyst in the chemical and petroleum industries, in the manufacture of electronic tubes and electrodes for inert-arc welders, as a refractory material, and in the manufacture of special optical glass.

The greatest potential 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}) if it is exposed to irradiation by neutrons in a reactor. The use of this 'Th_{232}-U_{233} fuel cycle' has many potential advantages in both advanced converters and breeder reactors, but the technology is presently at a very early stage of development compared with conventional reactor technology. Most authorities agree that it may be 1980 or 1985 before this future generation of reactors reaches the commercial stage.

* Rare-earth concentrates were also produced as a byproduct of uranium until late 1967; see 1968 Mineral Review No. 39, Rare Earths, by W.H. Jackson.

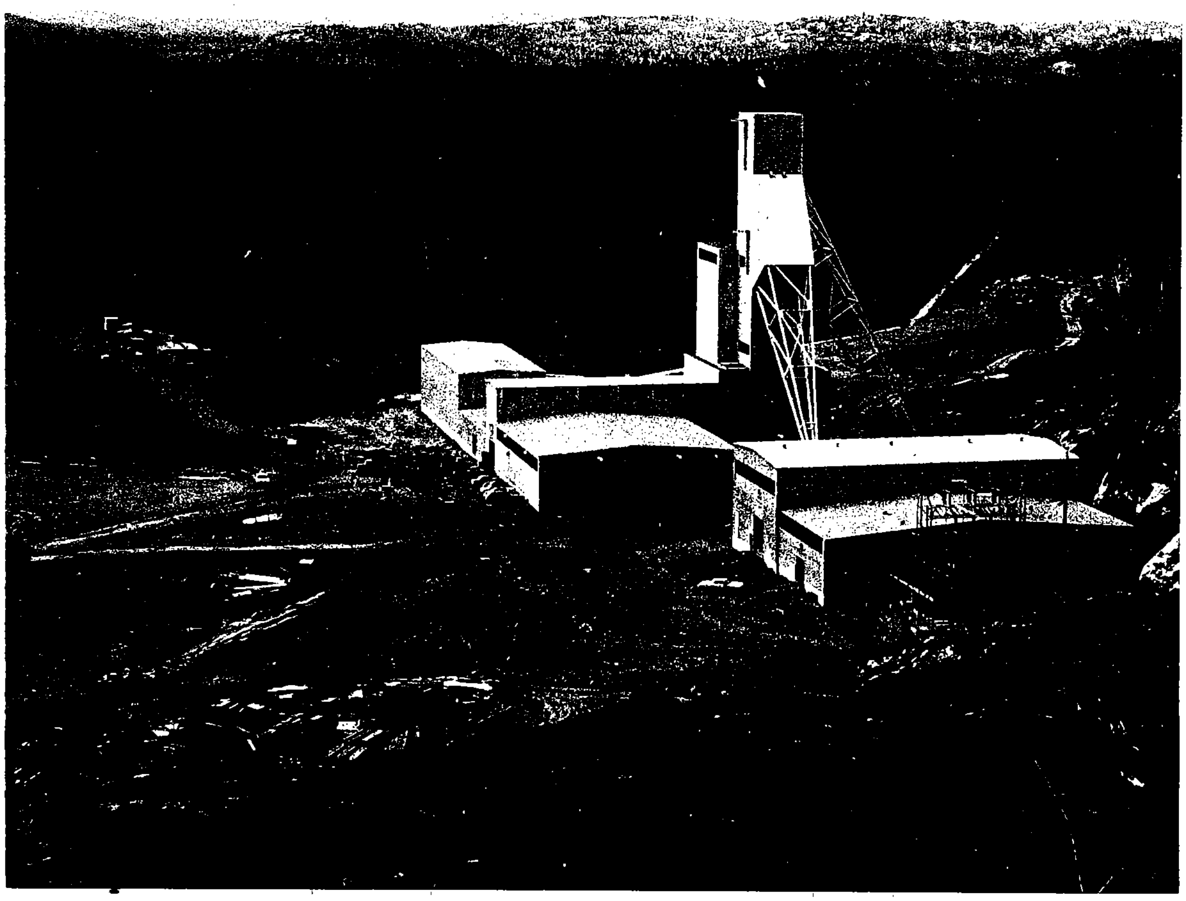
** 1 short ton ThO_2 = 795 kilograms of thorium metal.

† Thorium, by Richard F. Stevens, Jr., Engineering and Mining Journal, March 1969.

OUTLOOK

Although a minor increase in demand can reasonably be anticipated for thorium due to current and new industrial uses, a major increase in thorium consumption must await the full development of breeder and near-breeder reactor technology. Development of a commercial breeder reactor is not expected much before 1985 although commercial advanced converter (near-breeder) reactors could be operating somewhat earlier. The economic incentive for the development of these reactors is great and the benefits to be accrued through the resulting efficient use of energy resources are many. Consequently, while the requirements for thorium for nuclear purposes may amount to no more than 100 to 150 tons a year during the next 15 years, the demand can be expected to rise sharply thereafter. Canada, with some 80,000 tons of ThO_2 in presently known low-cost reserves, primarily available as byproduct material, is in an excellent position to benefit from this potential market.

AGNEW LAKE MINES LIMITED'S mine, under development some 30 miles west of Sudbury, Ontario. (Photo by EMR Staff)



Vanadium

G.P. WIGLE*

Vanadium is recovered in Canada, in small amounts, from crude oil, in the form of vanadium pentoxide (V_2O_5) by Petrofina Canada Ltd. at its oil refinery near Pointe-aux-Trembles, Quebec. The Petrofina byproduct plant recovers vanadium from fly-ash, collected from the burning of petroleum coke produced and used in the oil refining process. It is the only plant in Canada that recovers vanadium commercially. Capacity is about 1,000 pounds of V_2O_5 a day.

Production and consumption of vanadium in 1968 was higher than in 1967 but prices declined from U.S. \$1.05–\$1.15 a pound in January to 95 cents a pound in mid-1968, according to published quotations for merchants pentoxide (V_2O_5) for export, and remained at the lower price to the end of the year. United States standard grade ferrovanadium fell in price from U.S. \$3.45 to U.S. \$2.90 a pound of contained vanadium. Prices in Europe for fused pentoxide, 98 per cent V_2O_5, fell from 8 shillings 3 pence (8/3) a pound in January to 7 shillings 6 pence (7/6) in December.

The principal influences on the vanadium market were adequate supplies and growing new production from the Republic of South Africa and the United States. United States imports of ferrovanadium increased to a record of approximately 600 tons compared to 50 tons imported in 1967.

MINERALS AND OCCURRENCES

The more important of many known vanadium-bearing minerals are the complex sulphide, patronite; the vanadium-bearing mica, roscoelite; a potassium uranium vanadate, carnotite; the lead vanadates, vanadinite, descloizite and mottramite. Patronite with asphaltite found at Mina Ragra in the Peruvian Andes was an important source of vanadium 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 and Finland have become important sources, and large similar deposits are known in the USSR 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. A typical analysis of ilmenite from the Allard Lake area of Quebec shows 0.27 per cent vanadium pentoxide (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 in due course from the coke residue of the distillation process.

A recent publication of the Geological Survey of Canada, Paper 68-74, describes the first occurrences of uranium and vanadium in Prince Edward Island. The uranium vanadates rauvite and francevillite have been identified in greyish green sandstones which have similarities in their geology and geochemistry to uranium deposits in sandstones in the Colorado Plateau. The data available is not as yet sufficient to assess the economic significance of these discoveries which were made in November, 1968 by officers of the Geological Survey.

*Mineral Resources Branch.

TABLE 1

Canada, Imports and Consumption of Vanadium, 1967-68

	1967		1968p	
	Short Tons	$	Short Tons	$
Imports				
Ferrovanadium				
United States	241	1,075,000	106	437,000
Austria	27	131,000	59	157,000
Sweden	–	–	44	174,000
West Germany	3	23,000	32	116,000
Britain	18	79,000	22	92,000
Other countries	99	248,000	2	7,000
Total	388	1,556,000	265	983,000
Consumption				
Ferrovanadium				
Gross weight	274		. .	
Vanadium content	174		. .	

Source: Dominion Bureau of Statistics.
pPreliminary; – Nil; . . Not available.

TABLE 2

Production of Vanadium in Ores and Concentrates 1965-68
(short tons)

	1965	1966	1967p	1968e
United States	5,226	5,166	4,963	5,878
Republic of South Africa	1,519	1,711[1]	2,114[1]	2,340
South-West Africa	1,275	1,353	1,500e	1,500
Finland	1,063r	1,069r	1,292	1,300
Norway	750e	730e	740e	740
Other countries	1	–	–	. .
Total	9,834r	10,029r	10,069r	11,758e

Sources: U.S. Bureau of Mines, Minerals Yearbook 1967, and Mineral Industry Surveys. [1]From Minerals, a Report for the Republic of South Africa, Department of Mines, Johannesburg.
eEstimated; pPreliminary; rRevised; –Nil; . . Not available.

WORLD PRODUCTION AND CONSUMPTION

CANADA

Petrofina Canada Ltd. started vanadium recovery in 1965. 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 the manufacture of petroleum coke. Most of the vanadium in the crude 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 15 per cent 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.

Great Canadian Oil Sands Limited started oil recovery from the Athabasca tar sands near Fort McMurray in northern Alberta in September 1967. The operation will produce and use some 3,000 tons of petroleum coke a day in producing 45,000 barrels of oil a day. The ash from the coke is reported to contain about 4 per cent vanadium, most of which might be recovered in due course.

UNITED STATES AND THE REPUBLIC OF SOUTH AFRICA

Estimated non-communist world production of vanadium in 1968 was 11,758 tons, of which the United States produced 5,878 tons in 10,493 tons of vanadium pentoxide. Consumption in the United States was 5,251 tons compared with 5,060 tons in 1967. The steel industry used 89 per cent of the total consumed, nonferrous alloys (principally titanium-base alloys) used 6 per cent, and chemicals, and other uses 5 per cent. The amounts consumed in the common forms of supply are shown in Table 3. Table 4 outlines vanadium consumption in the United States by end use. United States production of vanadium is a byproduct of uranium mines in Colorado and New Mexico, of phosphorus production from phosphate rock in Idaho, and as a primary product from the new vanadium mining and milling complex of Union Carbide Corporation at Wilson Springs, Arkansas.

TABLE 3

Vanadium Consumed in the United States, 1967-68
(pounds of vanadium)

	1967	1968
Ferrovanadium	8,315,453	9,071,832
Oxide	260,262	266,858
Ammonium metavanadate	223,836	183,111
Other	1,319,752	981,661
Total	10,119,303	10,503,462

Source: United States Bureau of Mines, Mineral Industry Surveys.

The Republic of South Africa produced 3,775 tons of vanadium pentoxide in 1967 compared with 3,054 tons in 1966. The Vantra division of Highveld Steel and Vanadium Corporation Limited near Witbank in the Eastern Transvaal has a capacity of 6.5 million pounds a year of V_2O_5 recovered by chemical treatment of vanadium-bearing titaniferous magnetite. Highveld's integrated iron, steel and vanadium complex, also near Witbank, was progressively brought into operation during 1968. It is expected that production will reach rated capacity during 1971 and it is estimated that 480,000 tons of vanadium-bearing hot metal will be produced annually from which 23 million pounds of vanadium pentoxide will be recovered, in a slag containing 28 per cent V_2O_5, 10 per cent TiO_2, 42 per cent FeO and 20 per cent SiO_2. Ore reserves are reported to be about 200 million tons containing 55 to 57 per cent iron, 12 to 15 per cent titanium dioxide and 1.4 to 1.9 per cent vanadium pentoxide.

TABLE 4

Vanadium Consumed in the United States
by End Use, 1967-68
(short tons of vanadium)

	1967r	1968p
Steel:		
High-speed	486	378
Hot-work tool	92	76
Other tool	171	129
Stainless	45	48
Other alloy[1]	2,765	2,962
Carbon	814	1,039
Grey and malleable castings	30	25
Nonferrous alloys[2]	565	333
Chemicals	127	157
Other[3]	75	104
Total	5,170r	5,251p

Source: U.S. Bureau of Mines Minerals Yearbook, 1967 and U.S. Bureau of Mines Mineral Industry Surveys, Vanadium in December, 1968.

[1]Includes some vanadium used in high-speed or other tool steels not specified by reporting firms. [2]Principally titanium-base alloys. [3]Principally high-temperature alloys, welding rods, and cutting and wear-resistant materials.
pPreliminary; rRevised.

PRODUCTS AND USES

Vanadium is a steel-grey metallic element with a melting point of 1,900° Centigrade (3,450° F). Technical-grade vanadium pentoxide (V_2O_5) is the common product of primary vanadium producers. It is available as a fused black oxide, 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, 99.7, and 99.94 per cent. Ammonium metavanadate (NH_4VO_3) and vanadate of sodium are supplied to the chemical industry.

Vanadium is used principally as ferrovanadium, an additive, in the iron and steel industry. Its function is to reduce and control grain size, to impart toughness and strength, and to maintain hardness at elevated temperatures. Different grades of ferrovanadium are available with the vanadium content varying from 35 per cent to 85 per cent, carbon from 0.15 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. Ferrovanadium is produced by a reducing process using such reducing agents as carbon, silicon and aluminum in electric furnace or aluminothermic processes. Vanadium is generally used with other alloying elements in iron and steel rather than alone. Titanium-base vanadium alloys, having high-temperature strength qualities and good weldability, are used in the aircraft industries.

Compounds of vanadium are used in the chemical industry as catalysts in such processes as the production of sulphuric acid, and catalytic cracking of petroleum products. Other applications include the colouring of glass and ceramic glazes, as driers in paints and varnishes, processing coloured film, in welding rod, and in cutting and wear-resistant materials.

PRICES

Metals Week of December 30, 1968 quoted the following United States vanadium prices:

Vanadium pentoxide:		
	per lb V_2O_5, f.o.b. mine or mill, air dried	$1.30
	Dealer's (mainly export), f.a.s., per lb V_2O_5	.95
Ferrovanadium:		
	per lb V, packed, f.o.b. shipping point, freight equalized to nearest main producer	
	all grades	$2.90
	Solvan	$2.46
	Carvan	$2.46
Vanadium metal:		
	per lb 90%, 100-lb lots	$3.45

TARIFFS

		Most Favoured Nation	
		On and after Jan. 1, 1968	On and after Jan. 1, 1969
CANADA			
	Vanadium ores and concentrates come under 32900-1		
32900-1	Ores of metals, n.o.p.	free	free
35101-1	Vanadium metal, exc. vanadium alloys	13%	11%
37506-1	Ferrovanadium	5%	5%
37520-1	Vanadium oxide	free	free

TARIFFS (Cont'd)

UNITED STATES

601.60	Vanadium ore, concentrates	free	free
632.58	Vanadium metal, unwrought and vanadium scrap and waste (duty on scrap and waste temporarily suspended)	9%	8%
633.00	Vanadium metal, wrought	16%	14%
607.70	Ferrovanadium	11%	10%
422.60	Vanadium pentoxide	28.5%	25.5%
422.58	Vanadium carbide	11%	10%
422.62	Vanadium compounds, other	28.5%	25.5%
427.22	Vanadium salts	"	"

Sources: The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa. Tariff Schedules of the United States Annotated (1969), TC Publication 272.

Zinc

ROBERT J. SHANK*

Canadian mine production of zinc in 1968, totalling 1,285,142 short tons, 40,623 tons more than in 1967, established a record for the seventh consecutive year. Canada was the non-communist world's largest zinc producer with 29 per cent of the total.

Three mines, Ecstall Mining Limited near Timmins, Ontario, Pine Point Mines Limited at Pine Point in the Northwest Territories, and Brunswick Mining and Smelting Corporation Limited near Bathurst, New Brunswick, each in production less than 5 years, together accounted for over half of Canadian zinc output. The accompanying graph (Page 10) clearly shows that, since 1963, zinc mine production has expanded at an unprecedented rate.

About 36 per cent of mine output was smelted in Canada, the same as in 1967. The four domestic smelters turned out 426,918 tons of zinc in 1968, a gain of 5 per cent over 1967. Zinc concentrates produced in Canada in excess of requirements for domestic smelters, containing some 855,800 tons of zinc, were exported for treatment to 11 countries, primarily to the United States, Europe and Japan. Exports of refined zinc totalled 318,707 tons, two thirds of which went to the United States and Britain.

Canadian producers domestic shipments of refined zinc rose sharply from 109,983 tons in 1967 to 124,930 tons, a gain of 13.5 per cent.

At the beginning of 1968, the outlook for the year was for a surplus of zinc in the non-communist world, resulting in an expected increase of producers stocks, and possibly, a price decline. The International Lead and Zinc Study Group at its fall meeting in 1967 foresaw a statistical surplus of 220,000 tons in 1968 or about 7 per cent of production. These early forecasts of a zinc surplus were not realized for several reasons: production in the United States and Australia was curtailed by labour strikes; new plants in Europe experienced start-up problems and did not reach expected levels of output; and industrial demand, particularly in the automobile industry, became stronger than anticipated as the year progressed. In addition, a number of zinc smelters continued to operate at levels below capacity. As a result, total supply and demand in 1968 were again in approximate balance. Mine output by non-communist countries of zinc in 1968 was 4.4 million short tons, a gain of 2 per cent, while metal production was 4.0 million tons, a gain of 11 per cent. Consumption of zinc metal rose by 7 per cent in 1968 to 4.0 million tons. A small deficit, amounting to 23 thousand tons, was met by imports from communist countries, reduction of stocks, and releases from the United States government stockpile.

The Study Group at its meeting in November 1968 forecast a substantial increase in both mine and metal production of zinc in 1969, and a more modest rise in consumption. The group said, however, that forecasts made in previous years tended to overestimate production and underestimate consumption. Threatened spreads between the two did not always materialize because factors such as strikes and production difficulties had not been allowed for in the estimates, and because producers adjusted their output to consumers' demand.

* Mineral Resources Branch.

TABLE 1

Canada, Zinc Production, Trade and Consumption 1967-68

	1967		1968p	
	Short Tons	$	Short Tons	$
Production				
All forms[1]				
Ontario	268,532	77,820,698	345,555	97,446,411
Quebec	245,884	71,256,916	212,371	59,888,709
Northwest Territories	209,982	60,852,900	215,000	60,630,000
British Columbia	131,416	38,084,199	149,477	42,152,396
New Brunswick	151,356	43,863,241	133,303	37,591,486
Manitoba	36,258	10,507,674	44,602	12,577,992
Newfoundland	34,852	10,099,901	35,751	10,081,682
Saskatchewan	28,411	8,233,705	30,269	8,536,126
Yukon	4,739	1,373,151	2,430	685,260
Nova Scotia	23	6,707	72	20,135
Total	1,111,453	322,099,092	1,168,830	329,610,197
Mine output[2]	1,244,519		1,285,142	
Refined[3]	405,367r		426,918	
Exports				
Zinc, blocks, pigs and slabs				
United States	79,820	19,709,000	115,872	29,292,000
Britain	125,545	30,671,000	98,940	23,306,000
China (Mainland)	6,988	1,759,000	17,416	4,060,000
India	10,222	2,430,000	14,972	3,181,000
West Germany	3,149	776,000	8,120	1,922,000
Brazil	1,885	393,000	7,772	1,607,000
Philippines	3,924	917,000	5,324	1,180,000
Sweden	5,598	1,400,000	5,070	1,204,000
Argentina	907	198,000	4,114	875,000
Hong Kong	1,334	322,000	3,905	912,000
Japan	13,781	2,785,000	3,748	808,000
Belgium and Luxembourg	5.104	1,033,000	3,673	747,000
Iran	–	–	3,353	671,000
Venezuela	2,130	437,000	3,173	651,000
Taiwan	3,479	808,000	3,125	685,000
Other	33,786	7,868,000	20,130	4,310,000
Total	297,652	71,506,000	318,707	75,411,000
Zinc contained in ores and concentrates				
United States	359,806	43,071,000	365,475	42,284,000
Belgium and Luxembourg	190,527	22,696,000	208,397	22,916,000
Japan	72,757	9,688,000	98,671	12,071,000
Netherlands	26,838	4,214,000	50,345	6,014,000
West Germany	18,328	2,702,000	44,422	5,343,000
Britain	25,146	4,349,000	37,312	4,057,000
Norway	4,219	443,000	19,693	2,308,000
France	18,866	3,556,000	17,108	2,310,000
Poland	12,903	1,659,000	8,011	1,067,000
India	6,315	552,000	6,382	379,000
Italy	–	–	2	. . .
Total	735,705	92,930,000	855,818	98,749,000

TABLE 1 (cont'd)

	1967		1968p	
	Short Tons	$	Short Tons	$
Zinc fabricated materials, n.e.s.				
United States	3,143	1,256,000	5,884	2,005,000
Britain	367	137,000	605	167,000
Sweden	–	–	58	19,000
Trinidad and Tabago	39	17,000	42	15,000
Belgium and Luxembourg	12	11,000	10	15,000
Other countries	21	10,000	20	7,000
Total	3,582	1,431,000	6,619	2,228,000
Zinc and alloy scrap, dross and ashes (gross weight)				
United States	4,979	881,000	4,095	676,000
Belgium and Luxembourg	1,940	152,000	1,253	87,000
Britain	486	85,000	434	48,000
Netherlands	89	7,000	311	16,000
Republic of South Africa	–	–	119	7,000
Other countries	727	72,000	46	10,000
Total	8,221	1,197,000	6,258	844,000
Imports				
In ores and concentrates	75	10,000	128	12,000
Dust and granules	1,211	430,000	1,061	411,000
Slabs, blocks, pigs and anodes	1,065	317,000	1,518	315,000
Bars, rods, plates, strip and sheet	660	445,000	567	378,000
Slugs, discs, shells	137	58,000	163	70,000
Zinc oxide	1,703	523,000	1,648	524,000
Zinc sulphate	2,352	305,000	2,381	281,000
Lithopone	316	44,000	404	53,000
Zinc fabricated material n.e.s.	738	862,000	578	684,000
Total	8,257	2,994,000	8,448	2,728,000

	1967			1968p		
	Primary	Secondary	Total	Primary	Secondary	Total
Consumption						
Zinc used for, or in, the manufacture of:						
Copper alloys (brass, bronze, etc.)	11,460	18	11,478	..	..	..
Galvanizing						
electro	838	60	898	..	..	..
hot-dip	43,949	575	44,524	..	..	..
Zinc die-cast alloy	33,279	–	33,279	..	..	..
Other products (including rolled and ribbon zinc, zinc oxide)	18,253	2,055	20,308	..	..	..
Total	107,779	2,708	110,487	..	..	..

	1967			1968p		
	Primary	Secondary	Total	Primary	Secondary	Total
Consumers stocks on hand at end of year	8,975	576	–	..	..	..

Source: Dominion Bureau of Statistics.
[1]New refined zinc produced from domestic primary materials (concentrates, slags, residues, etc.) plus estimated recoverable zinc in ores and concentrates shipped for export. [2]Zinc content of ores and concentrates produced. [3]Refined zinc produced from domestic and imported ores.
[p]Preliminary; – Nil; n.e.s. Not elsewhere specified; .. Not available;
... Less than $1,000. [r]Revised.

CANADIAN SUPPLY AND DEMAND

MINE PRODUCTION

Output of zinc from mines in Ontario, Northwest Territories, British Columbia, Manitoba, Saskatchewan, Newfoundland and Nova Scotia increased during 1968 whereas less production than in 1967 was recorded from Quebec, New Brunswick and the Yukon Territory.

In New Brunswick, Heath Steele Mines Limited temporarily stopped producing zinc concentrates in October when fears of an oversupply of zinc were being voiced in the United States and underground conditions at the Heath Steele Mines permitted the mining of copper ores. In addition, the Heath Steele mill was closed for about a month in June, following cessation of the custom milling of ore from Cominco's Wedge mine, to permit changing the mill circuits over to treating only Heath Steele ore. Heath Steele has announced plans to raise its milling rate to 1 million tons annually by early in 1970, necessitating another interruption of milling operations for equipment installation late in 1969. Brunswick Mining and Smelting Corporation Limited treated more ore than in 1967 but a slight decrease in grade caused a drop in concentrate production.

One Quebec zinc producer, New Calumet Mines Limited, closed down its operation in 1968 and one new one, Bell Allard Mines Limited, was started. Lake Dufault Mines, Limited, completed mining most of its known high-grade ore, causing zinc production to be one third of that in 1967. Sinking was in progress, at Lake Dufault, on the new "Millenbach" shaft that will allow exploration of ore-grade diamond drill intersections, at a depth of about 4,000 feet, some 3 miles south of the present mine. A two-week strike in December by employees at Mattagami Lake Mines Limited resulted in a loss of production of 50,000 tons of ore. Surface diamond drilling has indicated the presence of a nickel-copper occurrence on the Mattagami Lake property.

The Geco Division of Noranda Mines Limited at Manitouwadge, Ontario, increased its zinc output by 35 per cent over 1967, due to a slightly higher tonnage treated and a better grade of ore. Production of zinc also rose by 35 per cent at Ecstall Mining Limited, a wholly-owned subsidiary of Texas Gulf Sulphur Company, reflecting a higher tonnage of ore milled. A small amount of development ore was sent for test milling by Big Nama Creek Mines Limited to Willroy Mines Limited, although the mine was not yet officially in production at year-end.

Hudson Bay Mining and Smelting Co., Limited operated the Flin Flon and Schist Lake mines at Flin Flon, Manitoba, and the Stall Lake and Chisel Lake mines at Snow Lake. The Osborne Lake mine, near Snow Lake, was brought into production at mid-year.

In British Columbia, Anaconda Britannia Mines Ltd. started work on a 2,200-foot deep internal shaft to develop a new ore zone for production. Operations at the two mines of Cominco Ltd. continued normally; production being slightly higher than in 1967.

Pine Point Mines Limited, a subsidiary of Cominco Ltd., continued to be the only zinc-producing mine in the Northwest Territories. Although the tonnage milled rose by 40 per cent, the grade of ore treated was about two thirds that of 1967, resulting in little change in overall zinc production. Direct shipments of high-grade ore were discontinued in December, 1968 as reserves of this material were depleted. Total production of contained metals is expected to be maintained at previous levels by the beginning of mining and milling of ore from the Pyramid mine early in January 1969.

Four new mines, with a potential annual output of about 240,000 tons of zinc contained in concentrates, are scheduled to start production in Canada during 1969. Anvil Mining Corporation Limited should begin operations at its large open-pit mine in the Vangorda Creek area of the Yukon Territory late in 1969. Delbridge Mines Limited should begin delivering ore to a custom mill late in the year also. The Pyramid mine of Pine Point Mines Limited is scheduled to start in January, and the Flexar mine of Hudson Bay Mining and Smelting Co., Limited in April, 1969.

Some indicated deposits that contain zinc, but for which production plans have not been announced, are listed in Table 4.

TABLE 2

Principal Zinc Mines in Canada, 1968 and (1967)

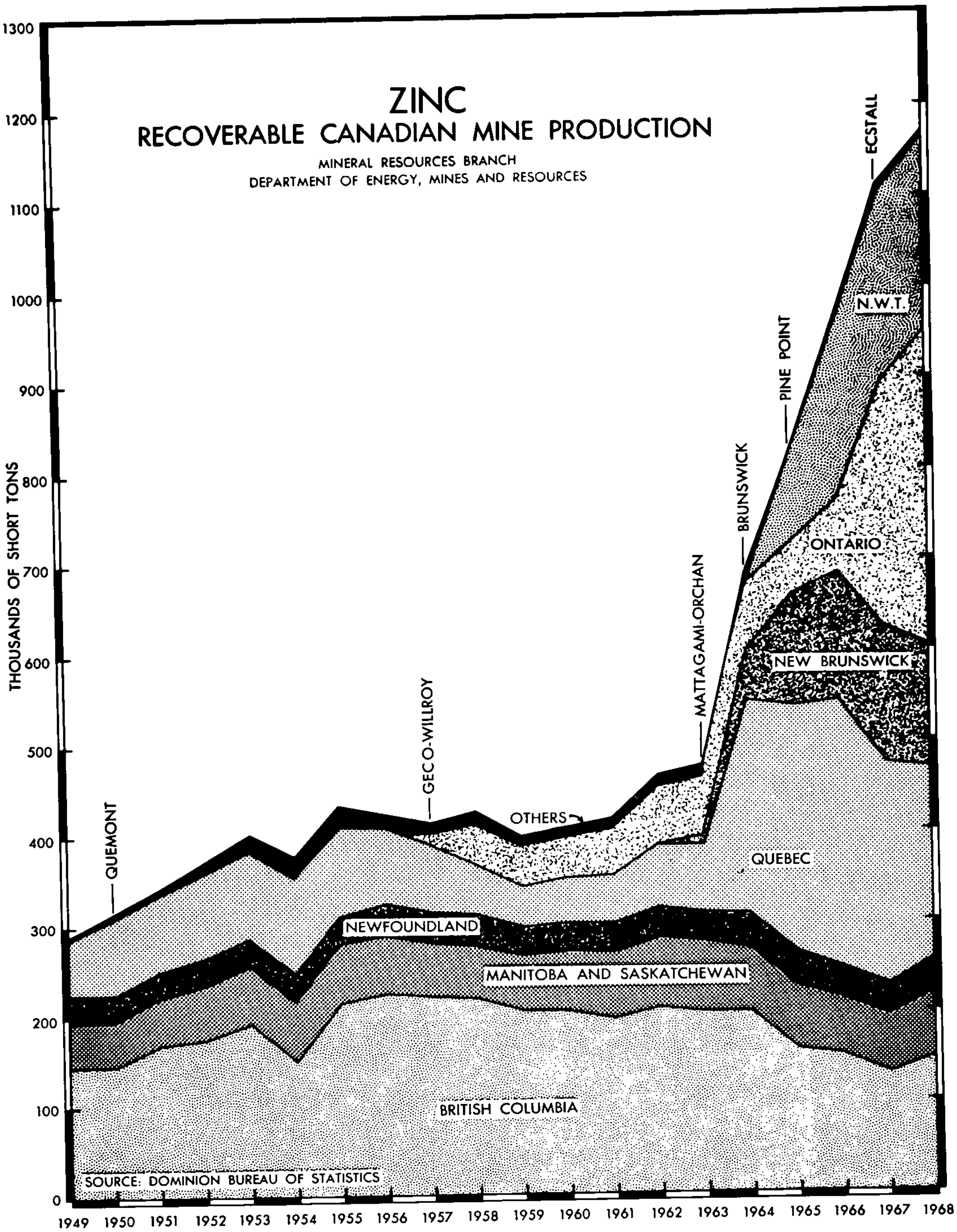
Company and Location	Mill Capacity (tons ore /day)	Grade of Ore: Zinc (%)	Grade of Ore: Lead (%)	Grade of Ore: Copper (%)	Grade of Ore: Silver (oz/ton)	Ore Produced (short tons)	Contained Zinc Produced (short tons)	Remarks
Newfoundland								
American Smelting and Refining Company, Buchans	1,250 (1,250)	12.83 (13.51)	7.14 (7.52)	1.11 (1.15)	3.93 (4.04)	378,000 (378,000)	45,322 (47,431)	Normal operations.
Nova Scotia								
Dresser Minerals Division of Dresser Industries Inc., Walton	125 (125)	0.26 (0.40)	3.80 (3.40)	0.40 (0.32)	7.10 (7.40)	49,786 (50,330)	. . (148)	Deepened shaft.
New Brunswick								
Brunswick Mining and Smelting Corporation Limited, Bathurst No. 6 Mine	2,500 (2,250)	5.66 (5.96)	2.47 (2.93)	0.35 (0.40)	1.53 (1.79)	984,280 (867,373)	41,185 (44,051)	Started mining third bench of open pit.
No. 12 Mine	5,000 (4,500)	8.56 (9.07)	3.38 (3.47)	0.27 (0.29)	1.92 (2.39)	1,724,465 (1,669,075)	112,057 (115,803)	Testing raise boring machine. Developing a high-production cut-and-fill stope.
Heath Steele Mines Limited, Newcastle	1,600 (1,500)	4.89 (8.87)	1.55 (2.71)	1.19 (0.56)	. . (2.64)	391,363 (308,866)	14,492 (23,699)	Milling of Wedge ore ceased in May. Mill overhauled, capacity increased. Production of zinc concentrates temporarily suspended in October. Mill capacity to be raised to 3,000 tons early in 1970.
Nigadoo River Mines Limited, Robertville	1,000 (1,000)	2.44 (2.06)	2.46 (2.15)	0.32 (0.43)	3.33 (3.22)	284,867 (22,630)	5,158 (205)	Finished milling ore from surface stockpile. Testing raise boring machine.
Quebec								
Bell Allard Mines Limited, Matagami	– –	10.16 –	– –	1.72 –	0.98 –	98,037 –	8,598 –	Commenced trucking open-pit ore to Orchan mill on April 1, 1968 at 11,000 tons a month.

TABLE 2 (cont'd)

Company and Location	Mill Capacity (tons ore /day)	Grade of Ore: Zinc (%)	Grade of Ore: Lead (%)	Grade of Ore: Copper (%)	Grade of Ore: Silver (oz/ton)	Ore Produced (short tons)	Contained Zinc Produced (short tons)	Remarks
Cupra Mines Ltd., Stratford Centre	1,500 (1,500)	3.75 (3.16)	0.47 (0.42)	2.81 (3.42)	1.21 (1.34)	225,702 (308,347)	6,298 (9,084)	Exploring new parallel zone. Developing D'Estrie property from Cupra workings. Milling Solbec ore.
Lake Dufault Mines, Limited, Noranda	1,300 (1,300)	3.94 (8.51)	– –	2.03 (3.96)	1.24 (2.53)	415,009 (492,938)	12,306 (34,386)	Sinking new shaft on D-134 zone. Mining lower-grade ore. Developing 'C' zone for mining. Mill being automated.
Manitou-Barvue Mines Limited, Val d'Or	500 (500) 800 (800)	2.21 (2.57) – –	0.07 (0.14) – –	– – 0.82 (0.70)	0.81 (1.34) 0.14 (0.10)	181,250 (181,350) 285,160 (294,640)	3,561 (4,109) – –	Developing additional zinc-silver ore to east. If sufficient tonnage found, may increase milling rate to 800 tons a day. Copper production 2,259 tons in 1968. Copper production 1,935 tons in 1967. Mining of copper ore to cease about May 1969. May convert copper circuit to handling custom ore.
Mattagami Lake Mines Limited, Matagami	3,850 (3,850)	10.00 (10.00)	– –	0.58 (0.61)	0.80 (0.85)	1,363,705 (1,414,136)	124,739 (128,250)	Developing No. 2 orebody. Stripping overburden from No. 1 orebody. On stream x-ray analyzer installed in mill.
Mines de Poirier inc., Joutel	2,500 (2,500)	2.10 (2.72)	– –	1.50 (1.25)	. . . .	566,551 (631,033)	8,053 (11,843)	Shaft deepened for seven new levels. Developing ore to west. Milling ore for Joutel Copper Mines Limited.
New Calumet Mines Limited, Calumet Island	800 (800)	6.64 (7.35)	2.06 (2.19)	. . (0.16)	4.18 (4.33)	70,476 (90,779)	4,539 (6,221)	Mine closed down October 31, 1968. Ore reserves exhausted.
New Hosco Mines Limited, Matagami	– –	2.50 (4.31)	– –	1.07 (1.36)	0.29 . .	327,715 (331,228)	5,815 (10,758)	Developing 'B' zone. Ore trucked to Orchan mill at 900 ton-a-day rate.
Normetal Mines Limited (formerly Normetal Mining Corporation, Limited) Normetal	1,000 (1,000)	7.33 (7.13)	– –	1.48 (1.50)	1.79 (1.55)	358,557 (348,440)	23,406 (21,789)	Assets purchased by Kerr Addison Mines Limited. Mining scheduled for completion by 1972.

TABLE 2 (cont'd)

Orchan Mines Limited, Matagami	1,900 (1,900)	10.62 (11.52)	– –	1.19 (1.19)	0.98 (0.98)	269,084 (375,135)	25,712 (39,829)	Treating ore from New Hosco Mines Limited and Bell Allard Mines Limited. Preparing to develop No. 1 orebody underground.
Quemont Mines Limited, (formerly Quemont Mining Corporation Limited), Noranda	2,300 (2,300)	2.09 (2.30)	– –	0.83 (0.98)	0.79 (0.78)	429,309 (443,774)	6,779 (7,650)	Assets purchased by Kerr Addison Mines Limited. Mining scheduled for completion by 1971.
Solbec Copper Mines, Ltd., Stratford Centre	– –	4.59 (4.54)	0.87 (0.78)	1.30 (1.39)	1.85 (1.69)	262,076 (75,310)	9,813 (3,148)	Routine mining of remaining ore reserves. Ore treated at Cupra mill.
Ontario								
Big Nama Creek Mines Limited, Manitouwadge	– –	5.08 –	0.11 –	0.87 –	1.21 –	10,655 –	424 –	Development ore trucked to Willroy mill. Orebody being opened by incline from surface.
Canadian Jamieson Mines Limited, Timmins	450 (450)	4.49 (5.23)	– –	2.86 (2.70)	. . . .	165,526 (139,666)	5,364 (4,657	Routine development and diamond drilling.
Ecstall Mining Limited, Timmins	9,000 (9,000)	9.55 (9.00)	0.50 (0.30)	1.57 (1.90)	5.19 (3.00)	3,614,860 (3,039,219)	305,747 (225,000)	Routine open-pit mining. Planning started for underground development and mining to initial 3,000 foot depth.
Kam-Kotia Mines Limited, Timmins	2,500 (2,000)	3.37 (1.76)	– –	1.37 (1.36)	0.20 . .	669,400 (679,677)	15,650 (6,710	Mill being expanded to 2,800 tons. Company developing Jameland Mines Limited for production.
Noranda Mines Limited, Geco Division, Manitouwadge	4,000 (3,700)	4.67 (3.69)	. . (0.13)	2.18 (2.02)	2.20 (2.02)	1,495,369 (1,461,000)	54,753 (40,497)	Developing orebody from No. 4 shaft.
Willecho Mines Limited, Manitouwadge	– –	3.43 (3.52)	0.26 (0.19)	0.44 (0.58)	2.15 (1.91)	346,444 (338,437)	9,354 (9,797)	Ore treated in Willroy mill. Incline driven to develop ore below bottom level.
Willroy Mines Limited, Manitouwadge	1,700 (1,700)	. . (3.33)	. . (0.12)	. . (0.66)	. . (1.25)	. . (165,053)	2,909 (4,532)	Exploring No. 7 and Slim Lake zones. Milling ore from Willecho and Big Nama Creek.
Zenmac Metal Mines Limited, Schreiber	200 (165)	17.30 (15.46)	– –	0.30 . .	. . . .	47,329 (60,162)	7,488 (8,635)	Exploring new 'C' zone in F.W. of main orebody. Small copper circuit installed in mill.



ZINC
RECOVERABLE CANADIAN MINE PRODUCTION
MINERAL RESOURCES BRANCH
DEPARTMENT OF ENERGY, MINES AND RESOURCES
THOUSANDS OF SHORT TONS
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
0
QUEMONT
GECO-WILLROY
OTHERS
MATTAGAMI-ORCHAN
BRUNSWICK
PINE POINT
ECSTALL
N.W.T.
ONTARIO
NEW BRUNSWICK
QUEBEC
NEWFOUNDLAND
MANITOBA AND SASKATCHEWAN
BRITISH COLUMBIA
SOURCE: DOMINION BUREAU OF STATISTICS
1949 1950 1951 1952 1953 1954 1955 1956 1957 1958 1959 1960 1961 1962 1963 1964 1965 1966 1967 1968

TABLE 3

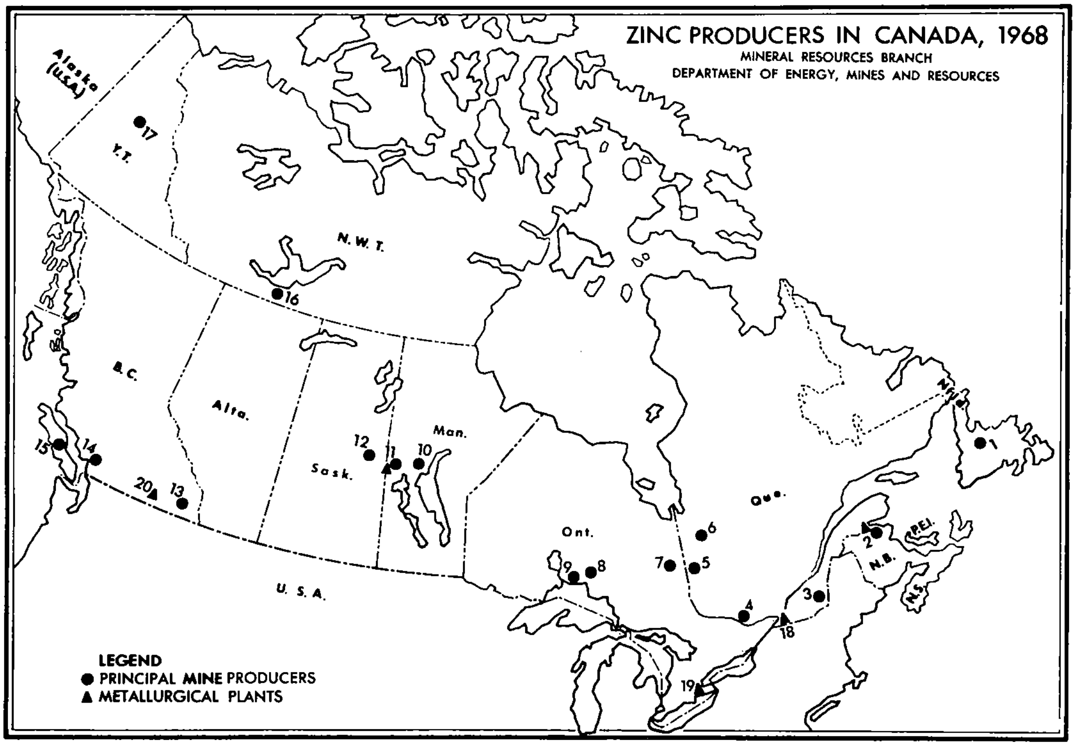
Prospective* Zinc Producing Mines in Canada

Company and Location	Year Production Expected	Mill Capacity (tons ore /day)	Indicated Ore Reserves (tons)	Grade of Ore				Remarks
				Zinc (%)	Lead (%)	Copper (%)	Silver (oz/ton)	
Quebec								
Delbridge Mines Limited, Noranda	1969	..	326,000	11.97	–	1.03	4.15	Production of about 500 tons a day to be treated in a nearby mill.
D'Estrie Mining Company Ltd., Stratford Centre	1970	..	300,000	4.25	0.94	3.81	1.31	Shaft sinking from Cupra Mines' 2050′ level to 4725′ level. Ore will be treated in Cupra mill.
Quebec Mining Exploration Company (SOQUEM), Val d'Or	1970	..	467,000	..	..	3.23	..	Planned production of 800 tons a day to be trucked to nearby custom mill. Will sink 1,000-foot shaft.
Ontario								
Jameland Mines Limited, Timmins	1970	..	750,000	7.21	–	1.70	..	Sinking production shaft to 1,300 feet. Ore will be trucked to Kam-Kotia mill at 20,000 tons a month.
Manitoba and Saskatchewan								
Hudson Bay Mining and Smelting Co., Limited, Flin Flon and Snow Lake								
Flexar mine	1969	..	241,700	0.40	–	4.11	0.13	Started production April 1969 at 210 tons a day
Anderson Lake mine	1971	..	1,781,500	–	–	3.79	0.17	Production at 1,000 tons a day planned.
Dickstone mine	1971	..	575,200	3.20	–	2.53	–	Constructing mine surface plant.
Sherritt Gordon Mines, Limited, Lynn Lake, Fox Lake mine	1970	3,000	12,269,000	2.35	..	1.74	..	Shaft being sunk to 2,350 feet. Japanese loaning preproduction capital.

TABLE 3 (cont'd)

Company and Location	Year Production Expected	Mill Capacity (tons ore /day	Indicated Ore Reserves (tons)	Grade or Ore				Remarks
				Zinc (%)	Lead (%)	Copper (%)	Silver (oz/ton)	
Yukon Territory								
Anvil Mining Corporation Limited, Vangorda Creek	1969	5,500	63,400,000	5.72	3.40	–	1.10	Preparing open-pit mine for production. Mill under construction.
Northwest Territories								
Pine Point Mines Limited, Pine Point, Pyramid mine	1969	3,000	11,200,000	8.00	2.50	–	. .	Started production January 2, 1969.

*Those with announced production plans;
–Nil; . .Not available.



PRINCIPAL PRODUCERS

(numbers refer to numbers on map)

1. American Smelting and Refining Company (Buchans Unit)
2. Brunswick Mining and Smelting Corporation Limited
   Heath Steele Mines Limited
   Nigadoo River Mines Limited
3. Cupra Mines Ltd.
   Solbec Copper Mines, Ltd.
4. New Calumet Mines Limited
5. Lake Dufault Mines, Limited
   Manitou-Barvue Mines Limited
   Normetal Mines Limited
   Quemont Mines Limited
6. Mattagami Lake Mines Limited
   Mines de Poirier inc.
   New Hosco Mines Limited
   Orchan Mines Limited
   Bell Allard Mines Limited
7. Canadian Jamieson Mines Limited
   Ecstall Mining Limited
   Kam-Kotia Mines Limited
8. Noranda Mines Limited (Geco)
   Willecho Mines Limited
   Willroy Mines Limited
   Big Nama Creek Mines Limited
9. Zenmac Metal Mines Limited
10. Hudson Bay Mining and Smelting Co., Limited – Chisel Lake, Stall Lake, Osborne Lake
11. Hudson Bay Mining and Smelting Co., Limited – Flin Flon, Schist Lake
12. Western Nuclear Mines, Ltd.
13. Canadian Exploration, Limited
    Cominco Ltd. – 2 mines: Sullivan, Bluebell
    Mastodon-Highland Bell Mines Limited.
    Reeves MacDonald Mines Limited
14. Anaconda Britannia Mines Ltd.
15. Western Mines Limited
16. Pine Point Mines Limited
17. United Keno Hill Mines Limited

METALLURGICAL PLANTS

2. East Coast Smelting and Chemical Company Limited, Belledune
18. Canadian Electrolytic Zinc Limited, Valleyfield
19. Sherbrooke Metallurgical Company Limited, Port Maitland
11. Hudson Bay Mining and Smelting Co., Limited, Flin Flon
20. Cominco Ltd., Trail

TABLE 4

Exploration Projects on Indicated Zinc Deposits

Company and Location	Indicated Ore Tonnage (tons)	Grade of Ore: Zinc (%)	Lead (%)	Copper (%)	Silver (oz/ton)	Remarks
Newfoundland						
American Smelting and Refining Company, Tulk's Pond	600,000	5.00	1.50	1.50	..	Property awaiting further plans.
Newfoundland Zinc Mines Limited, Daniel's Harbour	5,407,000	7.70	..	..	..	Exploration continuing.
New Brunswick						
The Anaconda Company (Canada) Ltd., Caribou property, Bathurst	..	..	..	..	..	25% owned by Cominco Ltd. Extensive underground exploration carried out. Exploration continuing.
Key Anacon Mines Limited, Bathurst	1,800,000	7.43	3.03	0.20	2.67	Former New Larder 'U' property. Shaft sunk to 1,500 feet with underground development.
Texas Gulf Sulphur Company, Half Mile Lake property	..	..	..	..	..	Property idle.
Manitoba and Saskatchewan						
Bison Petroleum & Minerals Limited, Brabant Lake	3,750,000	5.75	..	0.77		Property idle since 1966.
Copper-Man Mines Limited, Wekusko Lake	250,000	4.40	..	2.50		Western Nuclear Mines Ltd., carrying on exploration.
Hudson Bay Mining and Smelting Co., Limited,						
White Lake mine	352,500	6.20	0.50	2.22	1.12	Exploration continuing.
Ghost Lake mine	261,000	11.60	0.70	1.42	1.14	
Western Nuclear Mines, Ltd., Quandt group	900,000	1.77	..	2.16	0.20	Exploration continuing.
Stall Lake Mines Limited, Snow Lake	629,452	2.15	..	4.76	..	Falconbridge Nickel Mines, Limited is joint owner of this property. Exploration continuing.

TABLE 4 (cont'd)

Company and Location	Indicated Ore Tonnage (tons)	Grade of Ore				Remarks
		Zinc (%)	Lead (%)	Copper (%)	Silver (oz/ton)	
British Columbia						
Columbia River Mines Ltd., Golden	1,060,000	3.76	3.48	–	4.62	Production plans delayed pending financial arrangements.
Yukon Territory						
Hudson Bay Mining and Smelting Co., Limited, Tom deposit, MacMillan Pass	10,470,000	5.00	. .	–	. .	Property idle since 1953.
Kerr Addison Mines Limited, Swim Lake deposit, Vangorda Creek	5,000,000	9.5	(Pb & Zn)	. .	1.50	Possible production plans depend on results of feasibility study by Vangorda Mines Limited.
Vangorda Mines Limited, Vangorda Creek	9,400,000	4.96	3.18	0.27	1.76	Kerr Addison Mines Limited owns two thirds of Vangorda Mines Limited. Feasibility study being updated.
Northwest Territories						
Buffalo River Exploration Limited, Pine Point	1,350,000	9.60	3.40	–	. .	Production plans being considered.
Coronet Mines Ltd., Pine Point	1,100,000	13.2	(Pb & Zn)	–	. .	Exploration drilling being continued.

–Nil; . .Not available.

TABLE 5

Canadian Mine Output, 1967-68
(short tons)

	1967	1968p
Newfoundland	48,688	44,667
Nova Scotia	148	146
New Brunswick	183,696	172,930
Quebec	275,669	238,394
Ontario	300,190	388,605
Manitoba-Saskatchewan	61,889	77,099
British Columbia	134,870	136,555
Yukon Territory	6,135	3,107
Northwest Territories	233,234	223,739
Total	1,244,519	1,285,142

Source: Dominion Bureau of Statistics.
pPreliminary.

METAL PRODUCTION

Production of refined zinc at the four Canadian zinc plants in 1968 was as follows:

	Refined Zinc (short tons)*	Annual Capacity (short tons)
Canadian Electrolytic Zinc Limited, Valleyfield, Que.	111,460	140,000
Cominco Ltd., Trail, B.C.	209,994	263,000
East Coast Smelting and Chemical Company Limited, Belledune, N.B.	25,160	42,000
Hudson Bay Mining and Smelting Co., Limited, Flin Flon, Man.	80,304	79,000
Total	426,918	524,000

*From company annual reports.

TABLE 6

Canada, Zinc, Production, Exports and Consumption, 1959-68
(short tons)

	Production		Exports			
	All Forms[1]	Refined[2]	In ores and concentrates	Refined	Total	Consumption[3]
1959	396,008	255,306	184,742	179,552	364,294	64,788
1960	406,873	260,968	169,894	207,091	376,985	55,803
1961	416,004	268,007	199,322	208,272	407,594	60,878
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	337,728	403,102	238,076	641,178	88,494
1965	822,035	358,498	487,445	264,200	751,645	93,796
1966	964,106	382,612	591,322	256,153	847,475	107,052
1967	1,111,453	405,367r	735,705	297,652	1,033,357	107,779
1968p	1,168,830	426,918	855,818	318,707	1,174,525	124,930[4]

Source: Dominion Bureau of Statistics.
[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. [4]Producers' domestic shipments of primary refined zinc.
pPreliminary; rRevised.

Operations of the Canadian Electrolytic Zinc Limited (C.E.Z.) plant at Valleyfield, Quebec, were interrupted by a strike which lasted from April 13 to June 2. In order to assure a continuing and regular market for its byproduct sulphuric acid, C.E.Z. purchased and assumed the management of St. Lawrence Fertilizers Ltd. during the year. C.E.Z. treated concentrates for mines in Quebec and Ontario, some of which were Noranda's Geco mine and Mattagami Lake, Orchan, and New Hosco Mines. The electrolytic zinc plants of Cominco Ltd. at Trail, B.C., and Hudson Bay Mining and Smelting Co., Limited at Flin Flon, Manitoba, operated normally throughout the year. Zinc concentrates from Cominco's Sullivan and Bluebell mines were treated at Trail along with concentrates from Pine Point, Mastodon-Highland Bell, and other mines in British Columbia. Hudson Bay treats concentrates from its own mines as well as those from Western Nuclear and Zenmac. Revisions to the sintering machine and additions to the ventilation and dust removal equipment at the Imperial Smelting Process plant of East Coast Smelting and Chemical Company Limited at Belledune, N.B., were major factors that helped improve output from the plant. Further improvements to equipment and in results are planned for 1969. East Coast smelts zinc and bulk zinc-lead concentrates from Brunswick Mining and Smelting.

Canadian zinc reduction plants operated at about 81 per cent of their rated capacity during 1968. No plans have been announced to expand existing plants but Texas Gulf Sulphur Company has stated that Ecstall Mining Limited, a subsidiary of Texas Gulf, will build an electrolytic zinc plant near Timmins, Ontario, to treat about half of the zinc concentrates produced by Ecstall at its Kidd Creek mine. Construction of the plant, expected to cost $50 million, may be completed by late 1971 or early 1972.

CONSUMPTION

Per capita consumption of zinc in Canada, in 1968, at 12 pounds was up from 10.5 pounds in 1967 and compares to 13 pounds for the United States, 11 pounds for Japan, 11.5 pounds for Britain and 19 pounds for Australia. Of the total consumption of 124,930 tons of zinc in Canada, 41 per cent was estimated to have been used in galvanizing, 31 per cent in diecasting alloys, 17 per cent for rolled zinc, zinc oxide and other chemicals, and 11 per cent in the manufacture of brass.

It is not expected that the large gain in consumption of zinc in Canada that occurred in 1968 will be repeated in 1969, mainly because strikes in the automobile industry in 1967 adversely affected consumption for that year. However, most industry forecasters are predicting that the demand for zinc will increase by about 4 to 6 per cent annually in the foreseeable future.

TABLE 7

Canada, Producers Domestic Shipments of Refined Zinc, 1967-68
(short tons)

	1967	1968
1st quarter	23,927	29,918
2nd quarter	26,405	39,158
3rd quarter	29,348	24,342
4th quarter	30,303	31,512
Total	109,983	124,930

Source: Dominion Bureau of Statistics.

WORLD SUPPLY AND DEMAND

MINE PRODUCTION

Mine production of zinc in the non-communist world has increased each year since 1959 at an average rate of 5.5 per cent. Production in 1968, estimated at 4,380,000 short tons, was one per cent above that for 1967. Much of the nonferrous mining industry in the United States was closed by labour strikes during the first quarter of 1968 and later in the year, fears of an oversupply of metal caused some slight curtailment of operations. A series of one-day work stoppages in the Australian Broken Hill district mines was an important factor in the 5 per cent reduction in output from that country. Less output was also reported from Peru, Japan, Mexico, West Germany and Sweden.

New mines that started production in 1968 were the Silvermines mine in Ireland (85,000 tons a year of contained zinc for European smelters), the Huanzala mine in Peru (23,000 tons a year of contained zinc for Japanese smelters), and the Baiq mine in Iran (30,000 tons a year of contained zinc). Other new mines started, or were expanded, in Yugoslavia, Japan, Australia, Italy and Spain.

In 1969, the Anvil mine in Canada should start producing 130,000 tons of zinc annually for Japanese smelters; the Matilda mine in Bolivia, 55,000 tons also for Japanese smelters; new mines in Missouri in the United States, 30,000 tons for U.S. smelters; and the Rosh Pinah mine in South Africa, 20,000 tons for local treatment. New production will also come from Yugoslavia and Sardinia.

There is some fear that new deposits of zinc are not being found and developed rapidly enough to supply the required smelter feed over the medium to long term. A 5.5 per cent annual growth rate, based on 1968 production, would require about 240,000 tons of extra mine production each year, or about 480,000 tons of concentrates.

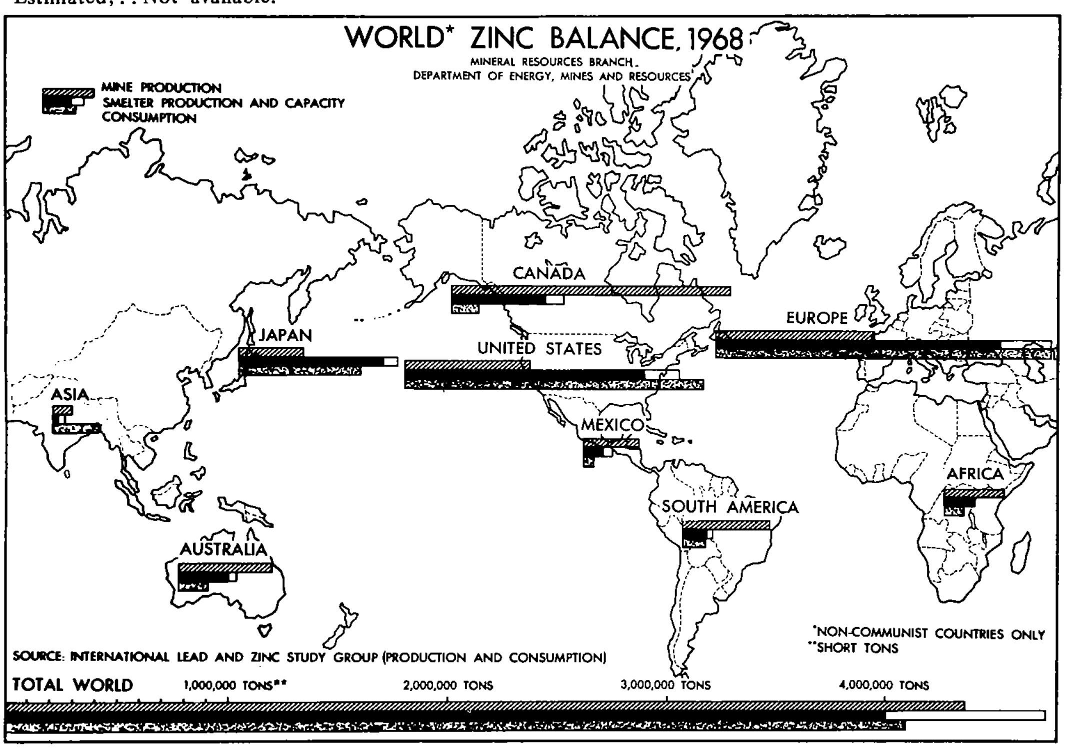
TABLE 8
World Mine Production of Zinc, 1967-68
(excluding communist-bloc countries)
(short tons)

	1967	1968
Canada	1,111,400	1,168,800
United States	603,700	530,300
Australia	412,500	391,300
Peru	350,400	303,100e
Japan	289,500	265,700
Mexico	260,800	240,900e
Italy	137,400	141,600
West Germany	142,600	133,900
Dem. Republic of the Congo (Kinshasa)	134,400	..
Yugoslavia	99,200	..
Sweden	84,500	74,600
Spain	65,100	71,300e
Finland	64,900	65,300
Zambia	59,900	..
Argentina	31,900	..
Other countries	449,400	..
Total	4,297,600	4,350,000

Source: International Lead and Zinc Study Group, March 1969.
eEstimated; .. Not available.

METAL PRODUCTION

World smelter capacity rose by 7.8 per cent during 1968 to approximately 4,750,000 tons. Smelter output of 4,020,000 tons was 85 per cent of effective capacity, compared to 83 per cent in 1967 and 89 per cent in 1966. At Avonmouth, Britain, the world's largest Imperial Smelting Furnace (I.S.F.) was blown in early in the year. It has a rated capacity of 120,000 tons of metal a year but operating difficulties kept output down during the run-in period. Another I.S.F., with an annual capacity of 55,000 tons of metal, came into production in Poland late in 1968. Electrolytic zinc plants of 120,000 tons, 35,000 tons and 18,000 tons capacity went into production at Datteln, West Germany; Port Pirie, Australia; and Udaipur, India. It is expected that an electrolytic zinc plant will be opened in South Africa (36,000 tons) in 1969, and that I.S.F.'s will start at Hachinohe, Japan (48,000 tons) in 1969 and Sardinia (60,000 tons) in 1969 or 1970. In addition to the above, expansions of existing plants in Norway, Spain, Japan and Mexico were scheduled for completion in 1968, and other companies in Japan, Italy, Yugoslavia and at Bartlesville in the United States are expected to expand their facilities in 1969. The Henryetta zinc smelter of Eagle-Picher Industries Inc. in the United States will be closed down during the next year because of



obsolescence. By the end of 1969, the non-communist world capacity to produce zinc metal should have risen another 6.6 per cent to approximately 5,070,000 tons.

CONSUMPTION

For the past 10 years, world consumption of zinc has grown at an average rate of 5.4 per cent. In North America, consumption is strongly influenced by the rate of automobile production. In the United States in 1968, about 43 per cent of zinc consumption was for diecastings, 36 per cent for galvanizing, 12 per cent for brass and the remainder for rolled zinc, chemicals or zinc dust. In Europe, however, the usage of zinc for diecastings and galvanizing in the auto industry has not reached the levels common in North America. The manufacture of brass consumes the most zinc in many European countries, closely followed by galvanizing, diecasting and other uses. There appears to be a trend developing for the European auto industry to use more zinc, a situation which could greatly improve world consumption. Japan follows the United States and Europe in consumption of zinc metal and is perhaps the fastest growing market.

TABLE 9

United States Consumption by End Use, 1967-68
(short tons)

	1967	1968p
Galvanizing	458,605	459,077
Brass products	131,537	157,965
Zinc-base alloy	535,118	549,457
Rolled zinc	45,443	45,287
Zinc oxide	29,774	34,937
Other uses	36,331	40,285
Estimated undistributed consumption	–	51,600
Total	1,236,808	1,338,608

Source: U.S. Bureau of Mines Mineral Industry Surveys, Zinc Industry in December, 1968.
pPreliminary; – Nil.

TRADE

The accompanying map, entitled World Zinc Balance, 1968, is an attempt to graphically portray zinc production and consumption by countries or groups of countries. It shows that Canada, Australia, South America, Mexico and Africa are the producers and exporters, each exhibiting the same characteristics; surplus mine production, somewhat less smelter production, and still less consumption. Europe and the United States are the large consuming nations, and along with Asia, show a need to import both concentrates and metal to satisfy their markets. Japan differs from both of the foregoing classifications in that it must import concentrates for its smelters, but, because of recent large smelter expansions, it has excess metal which it must export.

It appears obvious from the map that per-capita consumption of zinc in Asia, South America and Africa must be miniscule when compared to the industrialized nations. A new organization called "ZALIS", the Zinc and Lead International Service, has been formed in London, England with the purpose of stimulating the use of zinc (and lead) in developing nations.

ZINC USES

Zinc, when fresh, is a silvery-blue metal that becomes coated with an impervious grey oxide film when exposed to the atmosphere. It has a relatively low melting point, making it a leading metal for diecastings; good resistance to atmospheric corrosion combined with the third-highest place in the galvanic series of metals, resulting in its use in galvanizing; solubility in copper, making possible the manufacture of brass; inherent ductility and malleability, allowing it to be wrought and rolled, and adding these properties to its alloys.

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 in automobiles. Galvanized reinforcing rods are now in use in the construction industry, and galvanized structural members used in bridge construction save on painting and maintenance costs. Wire, pipe and numerous other articles are galvanized where protection is required.

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. 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.

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 constituent of the paper coating for coated paper electrostatic copiers. Zinc Oxide Company of Canada, Limited, a Montreal-based subsidiary of Hudson Bay Mining and Smelting Co., Limited, is the leading Canadian supplier. Zinc oxide is also used in compounding rubber and in making paint, rayon yarn, ceramic materials, inks, matches, and many other commodities. Zinc dust, which is a finely divided form of zinc metal, is used in the processes 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. From research being conducted, improved diecasting alloys are being introduced that will permit smaller castings to be made and speed up the diecasting process. A new alloy, called Prestal, has recently been developed. Prestal, 78 per cent zinc and 22 per cent aluminum, is reported to have a percentage elongation many times that of deep drawing steel. Because of this ductility, it is called a "superplastic" alloy that will find use in pressed parts for automobiles and appliances.

ZINC RESEARCH

Further progress was made at the Mines Branch (Department of Energy, Mines and Resources, Ottawa) on the galvanizing project which is co-operatively sponsored by the Canadian Zinc and Lead Research Committee and the International Lead Zinc Research Organization. The current phase is a fundamental study of the kinetics of the galvanizing reaction.

Principal effort was concentrated on construction and assembly of the hydrogen-atmosphere reaction apparatus, and on operational testing and calibration of ancillary components and services. Modification and design changes have largely overcome a variety of operating problems, and preliminary experimental runs are in hand to ensure adequacy and reproducibility of the experimental control techniques.

A summary report issued describes a prior phase of the project relating to elevated-temperature testing of commercially-galvanized thick-wall tube, angle, and bar products (Mines Branch Research Report R 200).

Results of a companion program on continuous-strip product were published elsewhere (Electrochemical Technology 6 (5), 330-336 (1968).

In the field of wrought alloys, co-operative work has been undertaken with two of the major zinc producers.

Zinc-aluminum alloys have been developed which have improved low-temperature impact properties, and which have been shown to be superplastic. Similarly, some additional work has been done on zinc alloys with improved creep resistance. The bulk of the work has been aimed at establishing optimum production conditions, and defining the range of properties which can be expected in a variety of industrial applications. (The present high cost of copper alloys makes substitution of zinc an attractive proposition in some instances.)

PRICES

There were no changes in the Canadian and U.S. domestic producers prices during the year, both quotations for Prime Western grade remaining at 13.5 cents a pound in their respective currencies. The overseas producer basis price, at which Canadian zinc sold outside of North America is priced, was unchanged at £114.33 a long ton, while the London Metal Exchange quotation fluctuated narrowly from £107-3/8 to £116 a long ton.

TARIFFS

The following Canadian and United States tariffs apply for zinc in its various forms.

	Before Jan. 1, 1968	After Jan. 1, 1968
CANADA*		
Zinc in ores and concentrates	Free	Free
Zinc, zinc spelter and zinc alloys in pigs, slabs, blocks, dust or granules	0.5¢ per lb	Free
Zinc anodes	7½%	Free
Dross and scrap for remelting or processing into zinc dust	Free	Free
UNITED STATES		
Zinc ores and concentrates	0.67¢ per lb on zinc content	

Unwrought zinc	
Other than alloys of zinc	0.7¢ per lb
Alloys of zinc	19%
Zinc waste and scrap (suspended to June 30, 1969)	0.75¢ per lb

*Most Favoured Nation tariff.

Source: Canada: The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa.
United States: Tariff Schedules of the United States Annotated (1969) TC Publication 272.

At the Kennedy Round of the General Agreement on Tariffs and Trade (GATT), Canada agreed to make certain changes in its tariffs rates as applied to zinc. Those changes pertaining to Most Favoured Nations are listed above. The United States tariffs on zinc items shown above were not changed.

Zirconium and Hafnium

G.P. WIGLE*

Canada does not produce zirconium or hafnium-bearing minerals but has many known minor occurrences of zircon (ZrO_2SiO_2) which is the principal mineral source of these two elements. Canada's use and consumption of imported zirconium metal, zirconium alloys, and zircon mineral concentrates have been increasing but, as yet, no domestic sources of the mineral have been developed.

Canada's imports of zirconium alloys were 220,165 pounds valued at $6.3 million in 1968 compared with 125,898 pounds valued at $3.2 million in 1967. The sharp increase in 1968, although important, was unusual and was due to a periodic surge in the delivery of structural material required to meet the needs of impending stages in the construction and installation of nuclear power reactors already undertaken in Canada.

Canada's nuclear and related industries achieved an important degree of integration with the completion of the initial stages of the zirconium ingot production plant of Eldorado Nuclear Limited at Port Hope, Ontario in late 1968. This new production facility, employing an advanced process developed by Eldorado will supply zirconium ingot metal and alloy for Canada's growing nuclear reactor power developments. Its nominal operating capacity is about 600,000 pounds of zirconium ingot a year which is estimated to be adequate for Canada's needs in the near future. The raw material used in the Eldorado process, and in previously established processes, is zircon sand concentrates principally from Australia, the largest producer of zirconium minerals.

Zirconium, in its pure state, is a relatively soft, ductile metal that has useful properties which have induced an increase in its production, and intensive study of the metal and its alloys. Its main commercial use is in the form of its principal mineral, zircon, in refractories, foundry moulding sand and in abrasives. Zircon is also used to produce zirconium metal, alloys and compounds. The metal is highly resistant to corrosion, has high-temperature strength, and a *low* absorption capacity (or high transparency) for thermal neutrons that makes it and its alloys of particular importance as a fuel-cladding 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 is, at present, for neutron control rods in nuclear reactors because of its *high* neutron absorption capacity. Zirconium allows relatively free passage of neutrons, 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 production of baddeleyite (ZrO_2) exceeded Australian production of zircon. Australia's production of zircon concentrates in 1967 was 330,122 tons with a zircon (ZrO_2SiO_2) content of 326,178 tons. Preliminary figures, subject to revision, reported by the Bureau of Mineral Resources, Geology and Geophysics, Canberra, show production of 347,099 tons and export of 298,055 tons of zircon concentrates in 1968.

*Mineral Resources Branch.

The United States is estimated to be the second largest producer of zircon and is the only very 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 imports of zircon concentrates reported by the Bureau of Mines were 59,303 tons in 1967 and an estimated 65,000 tons in 1968.

TABLE 1

Australia Zircon Production, 1960-68
(short tons)

	Zircon Concentrates	Zircon (ZrO_2SiO_2 content)
1960	114,645	113,673
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	330,122	326,178
1968	347,099	..

Source: Australian Mineral Industry, 1967 Review.
.. Not available.

TABLE 2

Australian Exports of Zircon Concentrates, 1966-67
(short tons)

	1966	1967
United States	67,796	70,870
Japan	33,874	62,704
Britain	33,476	34,627
Netherlands	22,050	23,885
Italy	18,471	23,268
France	29,746	16,299
Canada	..	10,993
Germany (F.R.)	6,943	9,755
Spain	..	6,191
Belgium	3,078	4,938
Others	20,245	13,310
Total	235,679	276,840

Source: Australian Mineral Industry, 1967 Review.
.. Not available.

PRODUCTS AND USES

The principal use of zircon is in steel and iron foundry moulds, mould facings and cores and as milled flour for mould and core washers, especially in the steel foundry production of castings with exacting specifications. Foundry consumption of zircon in the United States is now estimated to be less than 50 per cent of total domestic consumption of zircon sand concentrates. Silica sand, olivine and chromite are zircon's chief competitors in foundry use. The specifications for zircon sand supplied by Associated Minerals Consolidated Limited, of Southport, Queensland, Australia, are as follows:

Zircon Sand Specifications

	Per cent)
ZrO_2 (including HfO_2)	66.0 minimum
SiO_2	33.3 maximum
TiO_2	0.10 "
Fe_2O_3	0.15 "
Al_2O_3	0.15 "

Zirconium is used for other refractory applications as zircon sand and as zirconia (ZrO_2), prepared in bricks and refractory shapes. Milled zircon and zirconia are used as opacifiers in ceramic glazes, enamels, in electric insulators, pigments, abrasives, and in 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 gasolines, the cracking of hydrocarbons and crude oils. Zirconium tetrachloride is the principal intermediate chemical compound used in the manufacture of other zirconium compounds.

Zirconium metal, from which most of the small percentage of hafnium has 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 being installed at Pickering, Ontario, requires approximately 40 tons of zirconium in the initial installation and 7.0 tons a year for replacement fuel rods.

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. Its use in this application is because of its high neutron absorption cross-section (108 barns), which also makes necessary its removal from reactor-grade zirconium. The use of hafnium outside the field of nuclear technology is limited to specialized applications. These 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, photography flash powders, and as a component of explosive detonating caps.

MINERALS AND OCCURRENCES

Zirconium is widely distributed in nature, and although not one of the most abundant elements it is estimated to constitute 0.022 per cent of the earth's crust, which is more than the better known metals such as zinc, nickel, copper and lead. All zirconium minerals contain some hafnium. The two elements are very similar chemically and the presence of hafnium in zirconium minerals and purified compounds was not suspected for many years.

The most important zirconium mineral is the silicate, zircon (ZrO_2SiO_2). Due to its resistance to weathering and attrition, and specific gravity, it is found in beach deposits of heavy minerals in association with ilmenite, rutile and monazite. The oxide, baddeleyite (ZrO_2), is another important zirconium mineral which is found in Brazil where it occurs as alluvial pebbles and in nepheline-bearing rocks; and in South Africa where it is recovered as a byproduct of the processing of apatite ores. Zircon contains 64 per cent zirconia (ZrO_2) and about 2 per cent hafnia (HfO_2). Baddeleyite contains 98.8 per cent zirconia and 1.2 per cent or more 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 minable concentrations, except where weathering and reconcentration have occurred. It is a typical minor mineral constituent of pegmatites and nepheline syenites, occasionally appearing as local patches of crystalline zircon and cyrtolite. It usually occurs as shiny, stout, brownish crystals with low pyramids at the terminations.

Patches several square feet in area containing zircon crystals ranging from one-tenth 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. Small amounts of microscopic crystals, estimated at 0.2 per cent of the rock, occur in a band of mica-apatite-feldspar-pyroxene rock in Suzor Township near Parent, Laviolette County, also in Quebec.

The most important sources of zircon are 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 75 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 parts of the world including India, Republic of South Africa, USSR, 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 and a concentrating plant. The concentrating plant is floated on pontoons in the dredge pond, for large plants, but usually land-based in the case of small plants working on small isolated deposits. A fully-floating plant described by Associated Minerals Consolidated Limited has a capacity of 600 tons an hour when operating in normal dredging ground having an average grade of about 2 per cent heavy mineral. A smaller plant is built in sections, each on skids, so they can be moved by tractors to follow the dredging. The larger, fully-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. The overall 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 concentration and cleaning of the different mineral products to high-grade bulk and packaged concentrates. The products recovered by Associated Minerals Consolidated are Standard Zircon, Premium Zircon, Zircon flour, Ilmenite, Rutile, and Monazite. The zircon products contain a minimum of 66 per cent ZrO_2.

PRICES

	U.S. $ (Dec. 1968 & June 1969)
Zircon ore[1]	
sand, per long ton, c.i.f. U.S. ports, Atlantic ports, bags, 65% ZrO_2	70.00
Camden, N.J., bulk, 60% ZrO_2, per short ton	66.50 to 68.00
Domestic, Starke, Fla., bags, per short ton	56.00 to 57.00
Zirconium[1]	
per pound, f.o.b. shipping point, sponge, powder, platelets, low hafnium	7.00 to 14.00
commercial	5.00 to 10.00
Hafnium[2]	
sponge, per pound	75.00
rolled bar, plate, per pound	120.00

Sources: [1]*Metals Week;* [2]*American Metal Market.*

TARIFFS

CANADA

Item No.		Most Favoured Nation On and after Jan. 1/68	Most Favoured Nation On and after Jan. 1/69
34720-1	Zirconium, and zirconium alloys sponge and sponge briquettes, ingots, blooms, slabs, billets and castings in the rough	free	free
34730-1	Zirconium and zirconium alloys, bars, rods, sheet, strip, wire, forgings, castings and tubes, seamless or welded	free	free
92828-3	Zirconium oxide	5%	5%
92845-4	Zirconium silicate	free	free

Source: The Customs Tariff and Amendments, Department of National Revenue, Customs and Excise Division, Ottawa.

UNITED STATES

Item No.		On and after Jan. 1/68	On and after Jan. 1/69
601.63	Zirconium ore (incl. zirconium sand)	free	free
629.60	Zirconium metal, unwrought, waste and scrap (Duty on waste and scrap temporarily suspended)	11%	10%
629.62	Zirconium, unwrought alloys	13%	12%
629.65	Zirconium metal, wrought	16%	14%
422.80	Zirconium oxide	9%	8%
422.82	Other zirconium compounds	"	"

Source: Tariff Schedules of the United States Annotated (1969), TC Publication 272.

Company Index